

RESILIENCE OF CONSTRUCTION SMEs TO EXTREME WEATHER EVENTS

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Declaration

This thesis is submitted under the University of Salford requirements for the award of a PhD degree by research. Some research findings were published in refereed journals and as refereed conference papers prior to the submission of the thesis during the period of PhD studies (refer to Appendix - A).

The researcher declares that no portion of the work referred to in the thesis has been submitted in support of an application for another degree of qualification to the University of Salford or any other institution.

Gayana Wedawatta

Abbreviations

BACLIAT	-	Business Areas Climate Assessment Tool
BIS	-	Department for Business, Innovation and Skills
BCP	-	Business Continuity Planning
BoQ	-	Bill of Quantities
CREW	-	Community Resilience to Extreme Weather
DEFRA	-	Department for Environment, Food and Rural Affairs
EC	-	European Commission
EPSRC	-	Engineering and Physical Sciences Research Council
EWE	-	Extreme Weather Event
EWEs	-	Extreme Weather Events
IPCC	-	Intergovernmental Panel on Climate Change
JCT	-	Joint Contracts Tribunal
SME	-	Small and Medium-sized Enterprise
SMEs	-	Small and Medium-sized Enterprises
UK	-	United Kingdom
UKCIP	-	United Kingdom Climate Impact Programme
UNISDR	-	United Nations International Strategy for Disaster Reduction

Glossary of terms

Adaptation:	Initiatives and measures to reduce the vulnerability of SMEs to actual or expected climate change effects, including increases in the intensity or frequency of extreme weather events.
Adaptive capacity:	The ability of a SME to implement effective adaptation measures.
Coping capacity:	The ability of a SME to limit adverse consequences of EW hazards, using available resources and capabilities.
Coping strategies:	Actions that increase the ability to prevent, tolerate, avoid and/or recover from EWEs and impacts
Extreme weather event:	Meteorological conditions that are rare for a particular place and/or time
Extreme weather hazard:	A potentially damaging phenomenon associated with extreme weather that may cause loss of life or injury, property damage, social and economic disruption or environmental degradation.
Resilience (to extreme weather):	The ability to prevent, withstand, recover from and learn from the impacts of extreme weather hazards.
SME:	An enterprise which employs fewer than 250 employees and has an annual turnover not exceeding €50 million or an annual balance-sheet total not exceeding €43 million and is autonomous from a public body.

Vulnerability:

The characteristics and circumstances of SMEs that determine how susceptible they are to the impact of extreme weather hazards

Abstract

Small and Medium-sized Enterprises (SMEs), which form a significant section in many economies, are some of the worst impacted by the Extreme Weather Events (EWEs) and are considered to be the most vulnerable section of the UK economy to the impact of extreme weather. This is of particular importance to the construction industry, as an overarching majority of construction companies are SMEs who account for the majority of employment and income generation within the industry. Whilst construction has been perceived as a sector significantly vulnerable to the impacts of EWEs, the issues with regard to resilience of construction SMEs to EWEs have only been subjected to limited in-depth academic research. This study was developed to identify the growing need for improving the resilience of construction SMEs and sought to undertake an in-depth investigation of the issues.

Positioned within a pragmatic research philosophy, case study research strategy was adopted as the overall research strategy in undertaking this investigation. A mixed method research choice consisting of an exploratory questionnaire survey of SMEs and in-depth interviews of case study SMEs were employed to investigate the research questions which arose. The findings of the exploratory questionnaire survey indicated a lack of coping strategies among the construction SMEs studied. However, the in-depth case studies revealed that construction SMEs with significant previous EWE experience have, indeed, developed various strategies to address the risk of EWEs. A theoretical framework was developed to represent the resilience of construction SMEs to EWEs, informed by the findings of the study, where resilience was seen as a collective effect of vulnerability, coping strategies and coping capacities of SMEs, characteristics of the EWE and the wider economic climate. The study provides an original contribution towards the overarching agenda of the resilience of SMEs and policy making in the area of EWE risk management.

1 CHAPTER ONE - INTRODUCTION

1.1 Background to the study

The UK has been affected by a number of Extreme Weather Events (EWEs) during the recent past; 2005 heat wave, 2007 summer floods, and 2009 and 2010 heavy winter snowfall are some examples. In addition to such events that affected the UK nationally, parts of the United Kingdom (UK) were affected by a number of regional events during recent years (e.g. Cumbria floods in 2009). Such weather extremes have led to significant economic as well as societal costs. For instance, total economic costs of the 2007 summer floods were estimated at about £3.2 billion at 2007 prices, within a possible range of between £2.5 billion and £3.8 billion (Chatterton et al., 2010). Consequently, the insurance industry has paid over £3 billion in relation to the flooding in 2007 (ABI, 2008b) and over £365 million in relation to 2010's cold winter (ABI, 2010), providing evidence as to how costly weather extremes can be. It is claimed that there has been an increase in the intensity and frequency of such weather extremes during the recent years (Beniston and Stephenson, 2004; Thibault and Brown, 2008).

There is wide speculation that this increased intensity and frequency of EWEs is primarily due to intensified climate change and that there is a strong link between the two (Stern, 2007). Increases in the number and severity of EWEs are expected in the future, due to the impacts of climate change (Environment Agency, 2005; Munich Re, 2007; Stern, 2007). Consequently, costs of EWEs are also expected to escalate in future and the Stern review (2007) reveals that the average annual cost of extreme weather could reach about 0.5 - 1% of the world's GDP by the middle of the 21st century. Whilst many attribute the

increased costs of EWEs to the increase in the number and severity of EWEs, Kunkel et al (1999) argue otherwise. According to them, the world has become increasingly vulnerable to EWEs, rather than their numbers being increased. They argue that society has become more vulnerable to the effects of EWEs due to a variety of societal changes, including a growing population in high risk areas and large cities, more property subject to damage, and lifestyle and demographic changes subjecting lives and property to greater exposure.

Thus, the threat of EWEs has, and will become, a prime challenge to be dealt with by communities around the world. The significant scale of the risk of EWEs has made it important for communities to be able to adapt to the risk created by them and prepare for the disruptions caused by them (Helmer and Hilhorst, 2006). Resilience to EWEs has thus become an issue of significant importance to communities around the world, with the UK being no exception, as the risk of weather extremes are also expected to increase in future in the UK .

Various stakeholders in a community are affected at varying magnitudes by EWEs. Small and Medium-sized Enterprises (SMEs), which form a significant portion in many economies, are also affected by such events. The SMEs are often affected disproportionately by EWEs when compared with their larger counterparts (Tierney and Dahlhamer, 1996; Webb et al., 2000; Alesch et al., 2001). SMEs are, in fact, considered to be the section of the UK economy most vulnerable to the impacts of extreme weather (Crichton, 2006). Their vulnerability arises virtually by definition of the small scale of their human and financial resources (Bannock, 2005). SMEs, being highly vulnerable to the effects of EWEs, are required to be adequately prepared to face such events, in order to prevent, withstand and recover following such an event. Previous research reveals that

small businesses are not adequately prepared to cope with the risk of EWEs and other natural hazards and to recover following such an event (Tierney and Dahlhamer, 1996; Alesch et al., 2001; Yoshida and Deyle, 2005; Crichton, 2006; Dlugolecki, 2008).

SMEs may encounter unfavourable consequences if they are affected by EWEs, due to their increased vulnerability and not being adequately prepared to deal with such an event. Moreover, SMEs suffer even without having been directly affected by an EWE, due to the vulnerability of the supply chain, utilities and transport infrastructure (Burnham, 2006a). Indeed there is a view that the risks to the supply chain are some of the most important (Huddleston and Eggen, 2007). Improving the resilience of SMEs to the effects of EWEs has thus become an important issue, particularly with the increasing threat of EWEs. Being resilient to EWEs is particularly important to businesses due to the fact that they present businesses with positive consequences in addition to the negative consequences. Being resilient will allow businesses not only to minimise the threat of negative consequences but also to capture the positive consequences presented by EWEs. As far as SMEs are concerned, being resilient might well decide the survival or the failure of an SME affected, creating economic and social consequences. While the loss of an individual SME may not cause a significant impact on the local economy in terms of the earnings it generates or the number of people it employs, the collective losses of a number of small businesses from a weather extreme may devastate a local economy (Yoshida and Deyle, 2005).

This is of particular importance to the construction industry, given the fact that SMEs account for the bulk portion of employment (85%) and turnover generation (73%) in the industry (BIS, 2012). Hence, it is clear that the successful operation of SMEs is of

significant importance to the successful operation of the construction sector as a whole. Further, the need for more resilient structures and the need for reconstruction after the effects of a physically damaging weather event place a particular importance on the construction industry in terms of weather extremes. As construction activities are normally carried out in an open environment their activities are largely dependent on weather, unlike some other industry sectors. Thus, EWE resilience is a matter of significant interest to the construction industry. As the construction industry is overwhelmingly comprised of SMEs, SME resilience to EWEs has become an important aspect presenting many research opportunities.

1.2 Research problem

As discussed above, increased vulnerability to the effects of EWEs places SMEs at a higher risk when compared with their larger counterparts (Tierney and Dahlhamer, 1996; Webb et al., 2000; Alesch et al., 2001). As SME contribution is critical for the successful operation of local communities and economies, improving SME resilience against the effects of EWEs has become an issue which warrants considerable attention. Investigation of the business response to EWEs has long been neglected when compared with studies of the residential sector (Tierney and Dahlhamer, 1996; Tierney, 1997; Webb et al., 2002), and only a very few studies have looked specifically at SME response to EWEs. There seems to be an obvious gap between the increased need for improving SME resilience to EWEs and the current knowledge with regard to this issue.

As SMEs constitute more than 99% of businesses in the construction industry and as they generate more than half of the employment and turnover, SME participation is critical for the successful operation of the construction industry. Given that many large construction

projects involve a large number of SME participants, delivery of a successful project is dependent upon the involvement of these SMEs. Government studies into the construction industry (Latham, 1994; Egan, 1998), have in fact identified that the integration of the whole supply chain as a critical factor in improving effectiveness in the construction industry. EWEs are capable of creating disruption in the activities of the construction sector, not only via their direct physical effects but also via disruption to the supply chain of the industry. As the risk of EWEs is increasing, there is a growing need to prepare the construction industry's SMEs and their supply chain partners to face the challenges created by EWEs. Further, EWEs also present businesses with positive consequences as well (Soetanto et al., 2006; Heliview Research, 2008; Norrington and Underwood, 2008; Metcalf et al., 2009). It is important that SMEs are prepared not only to minimise the negative consequences, but also, to exploit the positive consequences presented by EWEs.

Whilst it can be argued that construction SMEs are likely to have risk management strategies in place against EWEs; particularly at project level, due to being in an industry that is highly reliant on the external environment and can easily be affected by EWEs, previous research suggests otherwise. For example, some of the recent studies have reported construction SMEs as the business sector that has been most adversely affected by EWEs (McWilliams, 2009; Wiseman and Parry, 2011). In fact, previous research has also reported construction SMEs to be one of the least prepared among SMEs against the impacts of EWEs. For instance, Norrington and Underwood (2008) reported construction SMEs to be the least prepared in terms of business continuity planning (Norrington and Underwood, 2008). This suggests that there is a general inertia amongst construction

SMEs to consider EWEs as a significant threat to their business activities and develop appropriate risk management strategies. Significant vulnerability to EWEs, coupled with the lack of preparedness, could critically affect the ability of a construction SME to withstand and respond to an EWE and survive following the event. This highlights the need for enhancing the resilience of construction SMEs to EWEs.

Berkhout et al (2004) reported that construction sector SMEs found it difficult to recognise and interpret climate change stimuli unless a frame of reference is available, such as previous experience of an EWE. However, as the previous research suggests, waiting until an EWE strikes could be too late, as some of the construction SMEs may not survive following the impacts of an EWE. Therefore, there seems to be scope to develop such a risk assessment tool which will aid construction SMEs to assess the risk of EWEs to their business activities.

Despite the gravity of the issue; resilience – or in most cases lack of resilience – of construction SMEs to EWEs, few studies have been undertaken to show how construction organisations have managed EWEs up to now. It can be argued that the lack of in-depth studies and evidence that suggests the critical nature of EWE risk to construction SMEs also contributes towards their lack of proactive decision making with regard to EWEs. This study was developed to address the aforementioned gap in the knowledge, identifying the growing need for improving the resilience of construction SMEs to the effects of EWEs. Justification for the study is further discussed in Section 2.6.4, following the review of extant literature.

1.3 General theoretical gap and the specific gap

Previous studies point out that EWEs are capable of creating a significant impact on SMEs (Webb et al., 2000; Alesch et al., 2001; Crichton, 2006). SME response to these events, however, has been subjected to limited academic research when compared with research into the residential sector (Tierney and Dahlhamer, 1996; Tierney, 1997; Webb et al., 2002). This issue; limited research on SME response to EWEs, forms the general theoretical gap identified for this research.

Within this general theoretical gap, a specific gap was identified with regard to construction SMEs response to EWEs. The construction industry is perceived as a sector highly vulnerable to EWE impacts (Mills, 2003; Crichton, 2006; McWilliams, 2009). However, there seems to be disagreement on this, as some perceive construction as less vulnerable to such impacts (Berkhout et al., 2004). The issues with regard to vulnerability of construction SMEs to EWEs, their coping capacity and coping mechanisms have only been subjected to limited in-depth academic research. It is therefore pertinent that this theoretical gap should be contextualised within the construction industry context. Within this specific theoretical gap, special attention is paid to supply chain issues related to EWEs, due to its significant importance. The study attempts to fulfil this gap in knowledge with regard to EWE resilience of construction SMEs.

1.4 Aim and Objectives

The aim of this research is to investigate the resilience of construction SMEs to the impacts of EWEs. The following objectives have been formulated in order to facilitate achievement of the aim of the research.

1. To examine the impacts of EWEs on SMEs in construction and other industry sectors.
2. To identify construction SME perceptions of EWE risk and their impacts.
3. To evaluate how the EWE risk is addressed by construction SMEs.
4. To assess the key issues that affect the resilience of construction SMEs to EWEs.
5. To develop and validate a decision making framework that can be used by construction SMEs to improve their resilience to EWEs.

1.5 Research questions

1. How do EWEs affect the activities of construction SMEs?
2. How do construction SMEs perceive the risk of EWEs, their impacts and vulnerability to EWE impacts?
3. How do construction SMEs currently cope with the effects of EWEs on them?
4. What are the factors that determine the resilience of construction SMEs to EWEs and how to improve their resilience to EWEs?
5. Can a decision making framework be developed to help construction SMEs to assess the risk of EWEs on their businesses?

1.6 Research methodology

Selection of an appropriate research methodology is of paramount importance in answering the research questions raised in order to achieve the objectives set for a research study. Accordingly, an overall approach to the entire study has to be established. This study was positioned within the philosophical positioning of pragmatism, where the research questions determine the epistemological stance. A mixed method research

approach was adopted where both the qualitative and quantitative data was collected and analysed to answer the research questions. Within an overall case study research strategy, a questionnaire survey was used as a forerunner to case study research, adopting a unique research design. The case study comprised two construction SMEs, and a construction project each under their operation. Within the case study strategy, semi-structured interviews were used as the primary data collection technique. Document analysis technique was also used therein. Interview data were analysed using content analysis and cognitive mapping techniques. These research methodological perspectives are discussed in detail in Chapter 3.

1.7 Contribution to knowledge

The main contribution to knowledge from this research will be the positioning of knowledge with regard to the resilience of construction SMEs within the construction industry body of knowledge. As discussed in the background (Section 1.1) and research problem (Section 1.2) sections, there is little in depth research on the resilience of construction SMEs to EWEs. The research seeks to relocate literature and knowledge which are otherwise fragmented across a number of disciplines within the construction management body of knowledge. The research will bring together knowledge from various disciplines such as SMEs, the construction industry, climate change, EWEs, disaster management, and business continuity to address the resilience of construction SMEs. In addition, the decision making framework to be developed will be of particular importance to the construction SME community as well as business support organisations and policy makers. The framework will highlight strategies for reducing vulnerability, implementing coping mechanisms and improving the coping capacity of construction

SMEs. The theoretical framework to be developed and populated, based on the evidence emerging from the study, will also make an original contribution, as the framework will present a novel approach to represent the resilience of construction SMEs. The contribution to knowledge arising from the study is further discussed in Section 7.3.

1.8 Contribution to CREW research project

This doctoral study forms part of the Engineering and Physical Sciences Research Council (EPSRC) funded “Community Resilience to Extreme Weather – CREW” research project. The CREW project sought to gain a better understanding of the effects of extreme weather events on local communities and to develop a set of tools for improving the resilience of local communities (See Appendix-B for a brief description about the CREW research project). The doctoral study contributed towards the PP2 programme package of the CREW research project, which sought to investigate how community groups; policy makers, households and SMEs, respond to EWEs and to study the complex relationships between these groups in order to improve the understanding of the impact that these relationships have on community resilience. Within this, the doctoral study informed the SME perspective of resilience to EWEs. Accordingly, whilst the doctoral study aimed to make an original contribution towards the EWE resilience of construction SMEs, by addressing a distinctive research aim, the study findings contributed to the CREW research project by informing the research work on SME resilience to EWEs.

1.9 Organisation of the thesis

The thesis is organised as follows;

1.9.1 Chapter 1 – Introduction

This chapter provides a general overview of the study and establishes the need for undertaking the study.

1.9.2 Chapter 2 – Literature review

The extant literature relating to the key issues pertaining to the study are discussed in the literature review section. The conceptual framework developed for the study will also be introduced here.

1.9.3 Chapter 3 – Research methodology

This chapter discusses the research methodological perspectives and where the study is positioned within these perspectives.

1.9.4 Chapter 4 – Findings and analysis of exploratory questionnaire survey

Findings of the exploratory questionnaire survey are discussed and analysed in this chapter.

1.9.5 Chapter 5 – Case studies from construction SMEs

Findings from case studies of construction SMEs; which involved semi-structured interviews and extended structured interviews will be discussed and analysed in this chapter.

1.9.6 Chapter 6 – Cross-case analysis and synthesis

Findings from individual case studies are followed by cross-case analysis, referring to exploratory questionnaire survey and literature. Development of the decision making framework is also discussed within the chapter.

1.9.7 Chapter 7 – Conclusion

Concluding remarks of the study and recommendations emerging from the study are discussed in this chapter, followed by identifying future research directions.

1.10 Summary and link

This chapter sought to introduce the research in hand and establish the ground for conducting the study. Research methodology adopted therein was also briefly introduced, which is addressed in detail in the Chapter 3. Literature, related to key issues that are linked to the study, are discussed in the next chapter.

2 CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

The previous chapter introduced the research study in hand and established the justification for undertaking the study. This chapter focuses on the review of existing literature pertaining to the key issues related to the study. The chapter is organised as follows;

1. Firstly, the literature pertaining to the EWEs in the context of the UK is presented and discussed.
2. Secondly, EWEs in relation to SMEs is discussed, followed by a discussion on SMEs in general and construction SMEs in particular.
3. Thirdly, the concepts of resilience and related issues such as vulnerability and coping capacity are discussed, in relation to the study.
4. Finally, the conceptual framework developed for the study is introduced, which is developed following the review of literature.

2.2 Extreme Weather Events

Francis and Hengveld (1998, pp 2) defined Extreme Weather (EW) as “weather that lies outside a locale’s normal range of weather intensity”. It was mentioned that, by definition, extreme weather is infrequent or rare. On a similar note, the Intergovernmental Panel on Climate Change (IPCC) defined Extreme Weather Events (EWEs) as events that are “rare within its statistical reference distribution at a particular place” (Parry et al., 2007 pp 875). Since the definition of “rare” itself can vary, the IPCC

definition went on to identify that an EWE “would normally be as rare as, or rarer than, the 10th or 90th percentile”. Notably, both the definitions distinguish the location or the place as an important variable in determining whether a particular event would amount to an EWE.

As this doctoral study forms part of the Community Resilience to Extreme Weather (CREW) research project, working terminology developed for the wider research project will be used here as applicable (See Annex-C for a summary of CREW terminology). Hence, EWEs are considered as “weather conditions that are rare for a particular place and/or time” (CREW Working Terminology) (Hallet, 2013). This definition resembles the other definitions mentioned above, and goes further to recognise that timescale is also important in determining how extreme or rare an event is. Although the word rare is used here as well, the term EWE is often used to refer to weather of sufficient severity to generate a hazard.

Examples for EWEs include extreme precipitation, floods, droughts, windstorms, extreme temperatures (both high and low) (Meehl et al., 2000), cyclones, heat waves and cold waves (Mirza, 2003). It is important to note that the term EWE is often used to encompass events like flooding and droughts; which in fact are EW hazards rather than EW conditions as referred to in the definitions above. An EW hazard is “a potentially damaging phenomenon associated with extreme weather that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation” (Hallet, 2013). For instance, flooding is a hazard rather than a weather condition itself, which could possibly occur due to a weather condition (heavy rainfall), coupled with other causes (e.g. inadequate drainage, overflowing river banks, etc).

However, the difference between a hazard and a weather condition is often neglected and the term EWE is used as an umbrella term to include weather related hazards as well. For example, the IPCC definition explicitly mentioned that EWEs “may typically include floods and droughts” (Parry et al., 2007). A similar stance is adopted in this doctoral research as well, where both weather conditions as well as hazards are embraced within the term EWE.

EWEs, as identified above, come in many different shapes and sizes (McGregor et al., 2005). The following sections briefly discuss the EWEs, which affect and are expected to affect, the United Kingdom (UK) commonly.

2.2.1 Types of EWEs

2.2.1.1 Flooding

Worldwide floods have become one of the costliest weather-related hazards, causing large scale human, economic and environmental damages during the recent past. Currently, according to the Association of British Insurers (ABI), worldwide floods are the second costliest, weather-related catastrophe after windstorms (ABI, 2005). Similarly, floods in Europe too seem to have become more destructive, and projections show that this tendency may become even more pronounced (Kundzewicz, 2005). The number of major floods in Europe has also risen from one per year between 1900 and 1974 to 15 a year between 1993 and 2001 (Dlugolecki, 2008). In the context of the UK the situation does not seem to be much different. In England alone, 5.2 million properties, amounting to one in six, are currently at risk of flooding (Environment Agency, 2009a). Flood risk in the UK is expected to further increase in the future (Evans et al., 2004), especially due to the impacts of climate change (Pitt, 2008). Evans et al (2004) identified that in addition to

climate change, urbanisation, environmental regulations, rural land management, increasing national wealth, and social impacts as the main drivers for increased future flood risk in the UK. Providing an estimate of how costly floods can be, the total economic cost of the 2007 summer floods; which affected several parts of the UK, was estimated at about £3.2 billion (Chatterton et al., 2010), when about 48,000 homes and 7,300 businesses were flooded (Pitt, 2008).

According to the UK Environment Agency (2009b), about 5.2million properties in England, amounting to one in six, remains at risk of flooding. Further, the national climate change risk assessment for the UK (HM Government, 2012) projects the risk of flooding to increase significantly in the future. Flood risk management is thus identified as an area that requires serious action within the next five years and beyond (HM Government, 2012). As it is neither technically feasible nor economically affordable to make the entire nation completely flood-proof (Environment Agency, 2009a), the Environment Agency recognises that, even with increased investment in flood risk management, about 0.5million properties will still be left at high risk of flooding by 2035, even under the most favourable of the future scenarios considered (Environment Agency, 2009b). This has resulted in a shift in the approach to flood risk management in recent years in the UK. Greater emphasis is now placed on non-structural flood risk management measures where at-risk communities are urged to adapt to flooding (Dawson et al., 2011; Pender and Faulkner, 2011). The Pitt Review recommended the take-up of property flood protection by businesses to enhance their business continuity against flooding (Pitt, 2008) and tasked local authorities to discharge these responsibilities under the Civil Contingencies Act 2004. This is of particular importance to SMEs, as they are increasingly

urged to address flooding and other EWEs in their business planning, rather than relying on community-level structural protection measures.

2.2.1.2 Temperature extremes

Global average temperatures have increased by nearly 0.8 °C since the late 19th century, and have been rising at about 0.2 °C per decade over the past 25 years (Jenkins et al., 2007). Central Europe experienced an unusually high summer temperature in 2003 due to a heat wave. It is now predicted that such extremely hot summers will become more common in future (Firth and Colley, 2006; Schar et al, 2004; Chase et al, 2006). According to Hulme et al (2002), even currently the hot summer days with daytime temperatures in central England exceeding 25°C have become more common, almost twice as many on average during the 1990s compared to the first half of the twentieth century. The Stern review (2007) estimates that there will be more days of extreme heat (relative to today) and fewer very cold days in the future, due to the effects of climate change. However, the UK experienced back to back cold winters recently, with temperatures plummeting below records. For instance, parts of the UK experienced their coldest temperatures for November (since the records have begun) in the year 2010 (BBC News, 2010a).

Temperature extremes may create adverse impacts on human health and may also create adverse effects on businesses. Firth and Colley (2006) report that the hot summer of 2003 caused major business disruptions and over 20,000 unexpected deaths, including over 2000 unexpected deaths in UK, directly attributable to the high temperatures. On the other hand, temperature extremes may give rise to many other environmental consequences such as droughts. Loss of harvest due to temperature fluctuations may create increased food prices as it happened in 2003 (Metroeconomica, 2004).

2.2.1.3 Extreme precipitation

Precipitation is the total quantity of water received by the earth's surface at a specific place during a specific time period. It includes rainfall and snowfall. All regions of the UK have experienced an increase in the contribution to winter rainfall from heavy precipitation events in past few decades (Jenkins et al., 2007). Referring to the studies of the Intergovernmental Panel on Climate Change, Ekström et al (2005) suggest that in the future there may be more intense rainfall events over many areas in Europe, the UK being no exception. Changes to the magnitude, character and spatial distribution of extreme rainfall may have serious social and economic implications (Fowler et al., 2005). The year 2012 was recorded as the second wettest year in the UK since records begun over 100 years ago, and the top 4 of the 5 wettest years have all been since the year 2000 (Met Office, 2013), suggesting that years with extreme rainfalls are increasing. Evidence suggests that the UK is receiving more rain in short bursts, with extreme rainfalls happening more frequently (Met Office, 2013). High intensity and long lasting rainfall episodes are recognised as major landslide triggering factors (Zêzere et al., 2008) and are expected to contribute to increased flooding (Kay et al., 2006).

The UK experienced a number of winters with heavy snowfall during the recent years. The heavy snowfalls of 2009, 2010, and 2012 are some examples. Heavy snowfall in January 2009 was estimated to lead to about 2000-3000 additional business failures (McWilliams, 2009), and the event was estimated to cost UK businesses about £1 billion (BBC News, 2009). These figures suggest how costly heavy snowfall can be for businesses.

2.2.1.4 Heatwaves

Heat or anomalously hot weather that lasts for several days, usually accompanied by high humidity is called a heatwave (Tan, 2008). Analysis of climate data has revealed that summer heatwaves have become more frequent in the UK (Hulme et al., 2002; Firth and Colley, 2006). It is predicted that they will become more frequent in future due to climate change (Department of Health, 2007), thus creating more severe impacts. As significant health impacts such as increased rates of mortality are associated with heatwaves, such impacts can be expected to further increase with the perceived increase of heatwave occurrences.

2.2.1.5 Droughts

Although droughts are not a common weather extreme experienced by the UK, some parts of the world commonly experience them. However, the climate change scenarios developed by UKCIP have identified that the risk of droughts occurring will increase in future, if climate change continues (Firth and Colley, 2006). The Stern review (2007) projects that serious droughts will occur more regularly in the UK, particularly in the South East region, as the water availability will be increasingly constrained due to decline of runoff in summer periods.

2.2.2 Risk of EWEs

The UK was affected by a number of Extreme Weather Events (EWEs) during the recent past. The heat wave of 2005, 2007's summer floods, and heavy snowfall in 2009 and 2010 are some examples. In addition to such events that affected the UK nationally, parts of the UK were also affected by a number of regional events during recent years (e.g. Cumbria floods in 2009). Such weather extremes have lead to significant economic, as

well as, societal costs. For instance, total economic costs of the 2007 summer floods were estimated at about £3.2 billion at 2007 prices, within a possible range of between £2.5 billion and £3.8 billion (Chatterton et al., 2010). Consequently, the insurance industry has paid over £3 billion in relation to the flooding of 2007 (ABI, 2008b) and over £365 million in relation to 2010's cold winter (ABI, 2010), providing evidence as to how costly weather extremes can be. It is claimed that there has been an increase in the intensity and frequency of such weather extremes during recent years (Beniston and Stephenson, 2004; Thibault and Brown, 2008).

There is wider speculation that this increased intensity and frequency of EWEs is primarily due to intensified climate change and that there is a strong link between the two (Stern, 2007). Increases in the number and severity of EWEs are expected in the future, due to the impacts of climate change (Environment Agency, 2005; Munich Re, 2007; Stern, 2007). Consequently, costs of EWEs are also expected to escalate in future and the Stern review (2007) revealed that the average annual costs of extreme weather could reach about 0.5 - 1% of world's GDP by the middle of the 21st century. Whilst many attribute the increased costs of EWEs to the increase in number and severity of EWEs, Kunkel et al (1999) argue otherwise. According to them, the world has become increasingly vulnerable to EWEs, rather than their numbers being increased. Their view was that society has become more vulnerable to the effects of EWEs due to a variety of societal changes, including a growing population in high risk areas and large cities, more property subject to damage, and lifestyle and demographic changes subjecting lives and property to greater exposure.

Thus, threat of EWEs has, and will become, a prime challenge to be dealt with by communities around the world. The significant scale of the risk of EWEs has made it important for communities to be able to adapt to the risk created by them and prepare for the disruptions caused by them (Helmer and Hilhorst, 2006). Resilience to EWEs have thus become an issue of significant importance to communities around the world, with the UK being no exception, as the risk of weather extremes are also expected to increase in future in the UK .

2.3 EWEs and SMEs

Various stakeholders of a community are affected at varying magnitudes by EWEs. SMEs, which form a significant sector in many economies, are also affected by such events. The SMEs are often affected disproportionately by EWEs when compared with their larger counterparts (Tierney and Dahlhamer, 1996; Webb et al., 2000; Alesch et al., 2001). SMEs are, in fact, considered as the most vulnerable section of the UK economy to the impacts of extreme weather (Crichton, 2006). Their vulnerability arises virtually by definition because of the small scale of their human and financial resources (Bannock, 2005). SMEs, being highly vulnerable to the effects of EWEs, are required to be adequately prepared to face such events, in order to prevent, withstand and recover following such an event. Previous research reveals that small businesses are not adequately prepared to cope up with the risk of EWEs and other natural hazards and to recover following such an event (Tierney and Dahlhamer, 1996; Alesch et al., 2001; Yoshida and Deyle, 2005; Crichton, 2006; Dlugolecki, 2008).

SMEs may encounter unfavourable consequences, if they are affected by EWEs, due to their increased vulnerability and not being adequately prepared to deal with such an

event. Moreover, SMEs suffer even without having been directly affected by an EWE, due to the vulnerability of the supply chain, utilities and transport infrastructure (Burnham, 2006a). Indeed there is a view that the risks to the supply chain are some of the most important (Huddleston and Eggen, 2007). Improving the resilience of SMEs to the effects of EWEs has thus become an important issue, especially with the increasing threat of EWEs. Being resilient to EWEs is particularly important to businesses, due to the fact that they present businesses with positive consequences in addition to the negative consequences. Being resilient will allow businesses not only to minimise the threat of negative consequences, but also to capture the positive consequences presented by EWEs. As far as SMEs are concerned, being resilient might well decide the survival or the failure of an SME affected, creating economic and social consequences. While the loss of an individual SME may not cause a significant impact on the local economy in terms of the earnings it generates or the number of people it employs, the collective losses of a number of small businesses from a weather extreme may devastate a local economy (Yoshida and Deyle, 2005). The following sections seek to identify the impact of EWEs on SMEs in detail.

Several recent studies have reported that a significant proportion of SMEs, subjected to studies in the UK, have been affected adversely by EWEs. For instance, a survey commissioned by Climate South East (Norrington and Underwood, 2008) revealed that about 54% of the SME respondents (based in South East of England) had experienced at least one weather extreme that had affected their business in the two years prior to the study. Heliview Research (2008) identified that about 37% of UK businesses subjected to their study had been affected by extreme weather in 2007. The UK has reported the highest percentage of businesses affected by extreme weather in comparison to 5 other

European countries in this study. Further, according to a study commissioned by Chartered Management Institute (Woodman and Kumar, 2009), 28%, 29% and 25% of UK businesses have experienced disruptions due to extreme weather in 2007, 2008 and 2009 respectively. The number of businesses affected saw a sharp rise in 2010, as 58% had reported that their businesses were affected by EWEs (Woodman and Hutchings, 2010). This is primarily due to the heavy snowfall which affected much of the UK during December 2009 – January 2010. The winter weather of 2011/2012 was identified as the major disruption faced by the UK businesses in the year 2012 (Pearson and Woodman, 2012). The above figures affirm that a significant proportion of SMEs in the UK have been affected by EWEs. The proportion of SMEs affected can be expected to further increase in future, as changing climatic conditions are forecast to increase such weather extremes (Environment Agency, 2005; Stern, 2007), emphasising the need for enhancing the resilience of SMEs.

2.4 SMEs

Before examining why the study of SMEs in relation to EWEs is important, it is intended here to obtain a better understanding of SMEs and their characteristics, especially as there still seems to exist some confusion as to what constitutes an SME. The following section attempts to review how literature defines an SME and to obtain a clear picture of what comes under the broad term SME.

2.4.1 Definition of an SME

Literature on SMEs reveals that a universally agreed definition of an SME is still to be arrived at (Lauder et al., 1994; Gunningham, 2002; BERR, 2007). The term SME covers a wide range of definitions and measures which vary across countries (Hallberg, 1999),

between the sources reporting SME statistics (Ayyagari et al., 2003), across time (Iffour, 2004; Lindner and Bagherzadeh, 2004), and different purposes (Gunningham, 2002) etc. These definitions can be broadly categorised as operational definitions and theoretical definitions (Hillary, 2000). Further, in many countries, there is also a distinction between the legal definition and the statistical definition (Lindner and Bagherzadeh, 2004). Some of the SME definitions are qualitative whereas others are quantitative. In general, quantitative definitions use one of three defining measurements; number of employees, turnover, and the size of the balance sheet (Lukacks, 2005; Anghel and Filip, 2007) to define a SME.

The term SME seems to be used as a catch all term to represent firms which are not “large” (Hillary, 2000). Traditionally, “small business” has been the term used for this purpose. Small firms form a part of the broad term SME and is a specific sub-category coming under many SME definitions. However, authors seem to use the terms “SME” and “small business” rather loosely and simultaneously, adding depth to the confusion as to what these are. This is especially so when it comes to qualitative and theoretical definitions, these two terms are often used synonymously.

Similar to the case of SMEs, there is no single and uniformly acceptable definition of a small business (Storey, 1994). Among many studies intended at arriving at a proper definition, the Bolton Committee Report of 1971 still remains as one of the most widely quoted sources of definitions and understandings of the small business sector (Tonge, 2001; Lukacks, 2005). The committee recognised that a “small firm could not be adequately defined in terms of employment or assets, turnover, output or any other arbitrary single quantity, nor would the same definition be appropriate throughout the

economy” (Bolton, 1971). Thus, the committee came up with an “economic” definition and a “statistical” definition to overcome these problems. The economic definition says a firm is a small business if it;

- Has a relatively small share of its market.
- Managed by its owners or part-owners in a personalised way.
- Does not form part of a larger enterprise and the owner-managers are free from outside control in taking their principal decisions.

Yet the economic definition is of no use for statistical purposes, since business statistics are not classified in terms of qualitative measures like market share, owner-managers and independence (Bannock, 2005). Therefore, the committee then defined a series of upper limits for small businesses, based on the industrial sector in which it operates, for statistical and descriptive purposes. Table 1 shows the statistical definitions adopted by the Bolton Committee.

Table 1 - Small firm sector as defined by the Bolton committee

Industry	Statistical definition of a small firm
Manufacturing	200 employees or less
Retailing	Annual Turnover ≤ £50,000
Wholesale trades	Annual Turnover ≤ £200,000
Construction	25 employees or less
Mining/ Quarrying	25 employees or less
Motor trades	Annual Turnover ≤ £100,000
Miscellaneous services	Annual Turnover ≤ £50,000
Road transport	Not more than 5 vehicles
Catering	All excluding multiples and brewery-managed public houses

(Source: Bolton, 1971, p 3)

Scott and Bruce (1987) have adopted the definition put forward by the American Committee for Economic Development which says a firm is small if;

- Management is independent. Usually the managers are also owners.
- Capital is supplied and ownership is held by an individual or small group.
- Area of operation is mainly local. Workers and owners are in one home community, but markets need not be local

This definition is in line with the qualitative definition recommended by the Bolton Committee Report to a certain extent. These qualitative definitions also highlight some major characteristics of small firms. They even provide some insights into the characteristics of the SME sector. For an example, Analoui and Karami (2003) have used the small business definition put forward by Bannock (1981) to define SMEs. They defined SME as “one that has only a small share of its market, is managed in a personalised way by its owner or part-owner and not through the medium of an elaborate management structure”. Likewise, qualitative definitions of small business are typically used by many authors to arrive at a general definition for SMEs.

Organisation for Economic Co-operation and Development (OECD) define SMEs as “non-subsidary, independent firms which employ fewer than a given number of employees” (OECD, 2000a; 2000b). It further says that this number (number of employees) varies across countries and national statistical systems. This is due to the fact that how SMEs are defined depends upon the scale and structure of business in an economy (Gibb, 2004). In most of the European Union (EU) countries, including the UK, the given number of employees is 250 whereas it is 500 in USA and 100 in Australia (Ayyagari et al., 2003). Therefore, it is important to identify SME definition from a regional perspective, and identify what is applicable for the region concerned. The EU and UK definitions of SMEs

are subsequently discussed, as these definitions are the ones applied for different purposes with regard to SMEs in the UK.

2.4.1.1 EU Definition

The European Commission, in its Commission Recommendation 96/280/EC, has defined a SME as “an enterprise which has fewer than 250 employees, and has either an annual turnover not exceeding €40 million or has an annual balance-sheet total not exceeding €27 million” (European Commission, 1996). This definition was superseded by the Commission Recommendation 2003/361/EC in order to take account of economic developments since 1996 (European Commission, 2006). Therefore the definition effective since 2005 is “an enterprise which employs fewer than 250 persons and which has an annual turnover not exceeding €50 million, and/or an annual balance-sheet total not exceeding €43 million” (European Commission, 2003). In this recommendation the SME category has been further sub divided into micro, small and medium-sized enterprises and the criterion adopted for the categorisation is given in Table 2.

Table 2 - EU categorisation of SMEs

Enterprise Category	Headcount: Annual work unit (AWU)	Annual Turnover	Annual Balance sheet Total
Medium sized	< 250	≤ € 50 million	≤ € 43 million
Small	< 50	≤ € 10 million	≤ € 10 million
Micro	< 10	≤ € 2 million	≤ € 2 million

(Source: The New SME Definition, 2006 p14)

Further, an enterprise loses its SME status if 25% or more of its capital or voting rights are directly or indirectly controlled, jointly or individually, by one or more public bodies (European Commission, 2006). If the organisation is not autonomous; i.e. if it is a partner

or linked enterprise, it has to consider the effects of its partners when calculating thresholds for categorisation. Thus, it is assured that categorisation is fair and only the needy are receiving aid, bearing in mind that one of the major objectives of the new definition was to ensure that support measures are granted only to those enterprises which genuinely require them (European Commission, 2006).

A major difference of the 2003 EC definition, from other such definitions, is that it uses the concept of “staff headcount” to measure the number of employees. The staff headcount is measured in “annual work units” (AWU) and takes into account the effect of different employment categories such as full-time, part-time and seasonal workers. Employees who do not work full time or throughout the year are counted as fractions of AWUs and thus more relief was allocated to these businesses.

The fact that the EC definition does not vary its definition according to the sector of the enterprise is favoured by some authors (e.g. Storey, 1994) whereas some (e.g. Hillary, 2000) argue that it may obscure characteristics of different SME sectors that more varied definitions try to draw out and may be unfair by businesses in some sectors. The EC sought to mitigate this by providing an option between the criteria of turnover and balance sheet total so that the SMEs engaged in different types of economic activities are treated fairly (European Commission, 2006).

Although a multi criterion categorisation is adopted in the legal definition, the main criteria used for statistical purposes is the number of persons employed (Lindner and Bagherzadeh, 2004). The EU definition corresponds to present statistics in accordance with the following size-categories of enterprise, which are parallel to the size-categories of the legal definition.

- 0 to 1 person
- 2 to 9 persons
- 10 to 49 persons
- 50 to 249 persons

Introduction of a categorisation for statistical purposes has standardised the statistical work on SMEs in the EU region, making it more convenient to access and analyse data as it adopts only a single criterion.

2.4.1.2 UK Definition

A study conducted by Ayyagari et al (2003) on SMEs worldwide reported that the UK does not have an official definition for an SME. Therefore, it is intended here to discuss some of the definitions used for different purposes.

Section 382 and Section 465 of the Companies Act 2006 define a small business and a medium business for the purpose of accounting requirements. A company is considered small or medium if two or more of the criterion specified (from turnover, balance sheet total and number of employees) is satisfied. Table 3 shows the criterion specified in the companies act.

Table 3 - Criterion for SME qualification under companies act 2006

	Turnover	Balance sheet total	Number of employees
Small	< £ 5.6 million	< £ 2.8 million	< 50
Medium-sized	< £ 22.8 million	< £ 11.4 million	< 250

(Source: UK Companies Act 2006)

Based on this categorisation, an SME can be identified as an organisation which employs not more than 250 employees and/or has an annual turnover of not more than £22.8

million and/or has a balance sheet total of not more than £11.4 million. Unlike in many other definitions, including the EU definition, here the upper limit of number of people employed is not a must to be satisfied. Therefore, an organisation which satisfies the turnover and balance sheet total requirements can still qualify as a SME even if it does not satisfy the employment requirement. However, as mentioned above, it has to be borne in mind that this categorisation has been derived mainly for accounting and reporting purposes. The financial threshold in the Companies Act definition has also changed considerably over the years in order to account for the country's economic developments.

The Department for Business, Innovation and Skills (BIS) mention that it adopts the EU definition of small, medium and large businesses (BIS, 2009b). Although the EU definition is adopted, BIS applies the size limit to employees, not to the headcount. For statistical purposes, BIS define an SME as "any enterprise with less than 250 employees" (BIS, 2010a). According to the Statistical Press Release (BIS, 2010b), an organisation is small if it employs between 0 - 49 number of people, and medium if it employs 50 - 249. While acknowledging the fact that SME definition can depend on several other factors outside this definition, it stresses that only the factor of number of employees is used in identification of SMEs for statistical purposes.

After looking at the different definitions available it becomes quite clear that it is difficult to come up with a universal definition for SMEs due to the significant differences that exist within the SME sector, different industry sectors, countries, and economies etc. This has created numerous difficulties for researchers studying SMEs (Curran and Blackburn, 2001). According to Storey (1994), researchers have attempted to resolve these

difficulties by tailoring or adjusting a definition according to the particular topic of the research. He further mentioned that multi-dimensional grounded definitions are appropriate for researchers to investigate managerial and behavioural aspects and that statistical definitions are appropriate where comparisons have to be made.

It is further evident that it is not possible to define SMEs adequately only in terms of a quantitative threshold or a qualitative statement alone. This has led to most definitions having two parts: Qualitative statement of the key characteristics of a small firm; and a quantitative proxy (Holmes and Gibson, 2001). Analoui and Karami (2003) have developed a definition, that is applicable to the UK context, after examining the general consensus within literature and through the combination of quantitative and qualitative approaches. They have defined an SME as an “enterprise employing up to 250 employees, having an annual turnover of up to £50 million, and management being independent and free from outside control in taking principal decisions”. Although this definition embraces both quantitative and qualitative measures and presents a combined definition, the upper limit of turnover recommended here is significantly higher than that of the Companies Act and the EU definitions.

Having considered the above definitions, it is proposed that the EU definition for SMEs be used for the purpose of this study. The EU definition seems more appropriate than any of the other definitions and is widely used in EU countries, including the UK. Further, adoption of the EU definition will allow more realistic comparisons to be made with SME statistics and results from other studies, as most of these are currently using the EU definition. Therefore, an SME is defined as “an enterprise which employs fewer than 250

employees and has an annual turnover not exceeding €50 million or an annual balance-sheet total not exceeding €43 million and is autonomous from a public body”.

However, from a practical perspective, it is often difficult to use the entire criterion to identify an SME due to the sensitivity of data such as turnover and balance sheet total. Therefore, it is proposed to use the employment criterion along with autonomy from a large organisation for the purpose of SME sample selection. This is due to the fact that from a policy viewpoint the characteristics of independently managed small businesses tend to be different from those of the small subsidiary firms of a large organisation (Gibb, 2004). Thus, the quantitative proxy of fewer than 250 employees and qualitative characteristic of being independent from a large organisation will be used to arrive at whether an organisation is an SME or not.

2.4.2 Characteristics of SMEs

Some of the major characteristics of SMEs are revealed through the discussion of their qualitative definitions in the previous section. This section seeks to discuss characteristics of SMEs further. Some of the characteristics are drawn from small business literature, as authors have generally used the term small business to represent businesses which are not large simultaneously and interchangeably with the term SMEs.

SMEs are a very heterogeneous group of businesses (Hallberg, 1999). They include a wide variety of firms ranging from village handicraft makers to computer software firms (Lukacks, 2005) operating in a wide variety of industry sectors ranging from traditional, established industries such as construction to newer sectors such as professional and scientific services (Tonge, 2001). Further, they differ greatly in size and other dimensions like turnover, growth rate etc. Hence, the differences between owner-managed small

firms with 10 or 20 employees and medium-sized, limited companies with over 200 employees will be greater than the differences between the latter and large, multidivisional organisations (Jones, 2003). The wide variety that exists among the SME community is what has made it difficult to make strong generalisations about the SME sector.

As identified in the previous section, much of the qualitative definitions of small business and SMEs are based on three major characteristics attributable to them; independence, personal management and limited market share. Limited market share not significant enough to influence national prices or quantities, personal management of owners where they actively participate in major aspects of the business and independence in decision making can be seen in most small businesses (Bannock, 2005). However, establishment of niches; especially by SMEs who provide highly specialised services or products, and delegation of leadership and opting for formal management structures are visible among some SMEs (Storey, 1994), which goes against the norms identified above.

A typical characteristic of small firms is their distinctive organisational culture stemming from the combination of ownership and management that typifies the majority of SMEs (North et al., 2001). This is why Bannock (2005) offers the argument that each small firm is unique. The vast majority of SMEs are owned by individuals or families (IFF Research Ltd, 2008), and thus the personal values of the owner(s) are necessarily integrated with the business and are reflected in the organisational culture.

Another typical characteristic of SMEs is that they are constrained by their limited internal resources, particularly with respect to finance, management resources and their knowledge-base compared with larger firms (North et al., 2001). It is also believed that

many smaller firms lack both managerial and technical skills (Tilley and Tonge, 2003). Such restrictions also act as obstacles for SME growth.

Curran and Blackburn (2001) discussed three major characteristics of small businesses identified by Wynarczyk et al. (1993), namely; uncertainty, innovation and evolution. Uncertainty is linked to small firms being price-takers, a vulnerability associated with having a limited customer base, lack of resources and general inability to withstand external influences on the way businesses are run. Innovation in small firms is linked with their ability to play a niche role and provide a marginally different product or service to the standard one provided by large firm. SMEs play a crucial role in the innovation process, in particular, by generating more radical innovation (European Commission, 2008), though they are much less likely to undertake research and development than a large firm (Storey, 1994). Evolution refers to the greater likelihood of a small business experiencing a greater range of changes than that which occurs in a larger firm during its growth. Scott and Bruce (1987) have identified five stages of growth in a small business; inception, survival, growth, expansion and maturity. They further declare that the role and style of management and the structure of the organisation changes drastically across these stages.

A significant majority of SMEs are local in their operations and rooted in local communities (Bannock, 2005). Yet, their markets need not be local (Scott and Bruce, 1987). Given the fact that a majority of SMEs are micro enterprises, and more importantly, have no employees (run by a self-employed owner manager or employee director), they are normally only in a position to operate in a local context. However,

many SMEs, especially medium-enterprises, supply products and services to customers in other markets and with the increased globalisation to markets in other countries as well.

SMEs often have more flexibility in their operations (European Communities, 2002). They can often be more flexible and responsive to customer needs than large integrated firms (OECD, 2000b), as large firms, unlike SMEs, are constrained by large investments, formal structures and procedures, etc. This distinct characteristic has allowed them to quickly adapt to changes happening in the business surroundings and gain competitive advantage, if they are willing to change.

In addition to the characteristics mentioned above, Holmes and Gibson (2001) have identified a list of characteristics including;

- Management and ownership is rarely separate
- Control over business operations and decisions resides with very few persons
- The equity in the business is not publicly traded
- The personal security of the owners is required to secure business debt; limited liability is rarely present
- The level and the number of formal contractual relations are kept to a minimum level
- Personal objectives of owners will guide and directly influence business decisions

2.5 Vulnerability of SMEs to EWEs

SMEs represent a significant proportion of the UK economy, not only in terms of numbers (over 99%), but also in terms of turnover (49%) and employment generated (59.8%) annually (BIS, 2010a). Important contributions to the UK economy are being made by the SMEs in terms of technological progress, increased competitiveness, creation of new jobs

and the economic revival of certain regions (Tilley and Tonge, 2003). Furthermore, SMEs are often said to contribute to a more equal distribution of income and wealth (Hallberg, 2000). SMEs, however, are said to be highly vulnerable to disruption due to various hazards such as Extreme Weather Events (EWEs). In fact, SMEs are considered as the most vulnerable section of the UK economy to the impacts of extreme weather (Crichton, 2006). Their vulnerability arises, virtually by definition, from the small scale of their human and financial resources (Bannock, 2005). Therefore, while extremes affect both large firms and SMEs equally, they may affect SMEs disproportionately hard (Tierney and Dahlhamer, 1996; Finch, 2004). In addition, a majority of SMEs are local in their operations and rooted in local communities (Bannock, 2005), thus their owners are often hit twice by EWEs; once as local citizens and also as business owners (Runyan, 2006).

Added to the increased inherent vulnerability, previous studies show that many small businesses are ill-prepared for recovery after a disaster (Yoshida and Deyle, 2005). Alesch et al (2001) in their study of small businesses response to disasters noted that a considerable proportion of small businesses affected by a disaster do not re-open following the event. According to them, many businesses who reopen do not manage to recover from the event, and close down within a short period of time. The economic impacts associated with such business failures will undoubtedly be substantial. While the loss of an individual SME may not cause a significant impact on the local economy in terms of the earnings it generates or the number of people it employs, the collective losses of a number of small businesses from weather extremes may substantially damage a local economy (Yoshida and Deyle, 2005).

On one hand, it is evident that some of the characteristics pertaining to SMEs contribute to their increased vulnerability to EWEs and other disruptions. On the other hand, some may argue that some of the characteristics pertaining to SMEs may actually increase their ability to respond and adapt to EWEs, leading to increased resilience. For instance, flexibility in operations and a flexible management structure may increase their ability to quickly respond to EW, rather than a larger enterprise. Before identifying how SMEs can respond to and are responding to the threat of EWEs, it is important to identify how SMEs are affected by EWEs. The following section serves this purpose by discussing how the SMEs are affected by EWEs.

2.5.1 Effects of EWEs on SMEs

Though the effects of EWEs tend to be negative in many obvious ways; for some systems in some areas, extreme events could be beneficial (Meehl et al., 2000). This is the case with businesses as well. Thus, it is intended that the next section will discuss both the negative and positive effects of EWEs. Most of these impacts are drawn from climate change and disaster studies as few studies are available with regard to EWEs and businesses.

2.5.1.1 Negative effects on SMEs

A recent report by Heliview Research (2008) identified increases in total cost and decreases in turnover as the main negative consequences suffered by European businesses due to EWEs in the 2007. It further revealed damage to buildings and other tangible assets, productivity losses, extraordinary costs and less profit as the other main negative consequences. Table 4 shows the findings of the study with regard to negative consequences experienced by businesses in 2007. More importantly, the study has

enabled the identification of a range of negative impacts that EWEs create on businesses, in a European context.

Burnham (2006a) also identified increased costs and loss of revenue as the main risks that businesses suffer due to EWEs. Increased costs may arise in many different forms. These may include, but are not limited to, higher costs of transportation, costs of alternative supply of goods and services, costs of premises improvements/relocation etc. On the other hand, SMEs may have to forego sales revenue due to business shutdown, reduced sales, productivity losses etc. They may also have to suffer increased costs and loss of sales revenue due to the vulnerability of the supply chain, utilities and transport infrastructure (Tierney, 1995; Burnham, 2006a). Businesses may not be able to receive supplies in time and may not be able to deliver goods on time due to the effects of EWEs such as flooding, storms and heavy snowfall.

Table 4 - Negative influences experienced by businesses due to extreme weather events
(Source: Heliview Research, 2008 pp 17)

Negative influence / impact	Percentage of businesses affected
Increase in total cost	54%
Decrease in turnover	43%
Damage to buildings and other tangible assets	20%
(Labour) productivity losses	19%
Extraordinary costs	19%
Less profit	19%
No unfavourable consequences	12%
Disruption in supply chain	12%
Loss of clients	11%
Decrease in product demand	6%
Product differentiation / adaptation	6%
Closing of part of the business	4%

ICT related problems	2%
Other	8%

Another recent study conducted on behalf of Climate South East (Norrington and Underwood, 2008) identified that damage to property/stock and reduced customer visits/sales are the negative EWE impacts most experienced by South East SMEs in the past two years. Furthermore, it is now widely agreed that the risks of blackouts and damage to property and contents from EWEs are increasing (AXA Insurance UK, 2008). Damage to business premises or contents can affect the ability of a business to survive, not only because of lost sales or lost production hours, but also because of increased costs such as alternative premises, overtime etc (Association of British Insurers, 2008). Furthermore, damage to property may create business disruptions, eventually giving rise to more costs. The impacts of business interruption include the costs incurred replacing or repairing the assets, the loss of revenue during the disruption period as a result of inability to produce and sell particular products and complementary products, and loss of revenue from all products due to perceived loss of quality etc (Aba-Bulgu and Islam, 2007). For an SME, these costs can be substantial.

On top of the initial direct loss of cash flows, SMEs may also experience other forms of crises such as loss of market share, loss of key personnel, loss of production efficiency, withdrawal of supplies, withdrawal of licences, and loss of quality/standard accreditation and so on (Aba-Bulgu and Islam, 2007). Tierney (1997) pointed out, that in addition to direct physical impacts and the interruption of critical utility services, disasters cause business losses by affecting productivity in other ways, for example, by disrupting customer traffic and causing problems for employees. It is further revealed that losses

escalate when employees cannot travel to work because of transportation and other problems, when owners must suddenly cope with losses both at home and within the business, when customers cannot purchase goods and services, and when the flow of supplies and materials is disrupted.

EWEs driven by climate change such as extreme temperatures, extreme rainfall etc. may experience decreased demand for certain goods and services. Loss of traditional markets, loss of local competitive advantage and new competition in existing markets in the agriculture sector industries can be cited as an example (Metcalf and Jenkinson, 2005). Some regional industries may suffer due to the enhanced position of competitors in other regions. SMEs operating in such vulnerable business activities may be adversely affected. Businesses which do not apply adaptive measures against weather extremes may face the risk of attracting and retaining staff due to their reputation as a poor employer (Metcalf and Jenkinson, 2005). Furthermore, climate change impacts might result in the relocation of workers, or changes in commuting patterns (London Climate Change Partnership, 2002). Businesses may face problems with regard to these issues.

Difficulty in securing finance and obtaining insurance cover at reasonable cost are also negative effects that SMEs may have to face (Metcalf and Jenkinson, 2005). The investors and credit suppliers will be reluctant to supply finance (Metcalf and Jenkinson, 2005) and the insurers will quote a higher premium for cover if the possibility of damage to a business due to an EWE is high (Dlugolecki, 2004). Furthermore, it is expected that the insurance premiums that deal specifically with losses due to weather extremes will increase, in general, due to the increased risk of EWEs (Association of British Insurers, 2005). For instance, Wedawatta et al (2012) reported that SMEs in Cockermouth affected

by the 2009 flood event have experienced significant increases in their insurance premiums and excesses, following the flood event. Therefore, the additional cost of higher premiums presents another severe risk for SMEs who may be tempted to under-insure their assets, leaving them vulnerable to further losses in the event of further EWEs, hence creating a vicious cycle. AXA insurance (2008) revealed that 90% of small businesses are currently under-insured. Businesses, particularly SMEs, whose powers of negotiation are lower when compared with large-scale organisations will suffer losses for these reasons.

Alesch et al (2001) have found that only the weakest, small businesses fail right after a disaster. They reveal that many owners continue to struggle to recover until, one by one, their resources, energy, and their options are exhausted, leading to more economic and social losses. Therefore, EWE-struck SMEs who struggle to recover but ultimately fail may suffer further losses in addition to those initial incurred.

The above discussion reveals some of the negative impacts that SMEs may face due to EWEs. The amount of losses suffered by individual organisations may vary to a great extent depending on many factors. As an example, Webb et al (2002) state that businesses in crowded, highly competitive, and relatively undercapitalised economic niches appear to have the most serious problems. Alesch et al (2001) point out that the initial losses experienced by a small business depend on four factors: exposure; vulnerability; intensity and the duration of the event; and the amount of warning time available. Furthermore, the effects on a small business may vary according to the type of EWE and the industry sector and locality in which it operates (Metcalf and Jenkinson, 2005).

Impacts of flooding on SMEs

As identified in Section 2.2.1.1, flooding is an EWE that has a significant risk profile and occurs repeatedly in the UK. Therefore, whilst the focus is on EWEs in general, flooding is given special attention due to the significant impact that it can have on SMEs, and the current relevance to policy and practice.

Damaged or lost stock, damage to buildings/premises, damaged or lost building equipment, inability to conduct business, and inconvenience to staff were the main short term impacts experienced by small businesses in Yorkshire affected by the summer floods of 2007 (EKOS Consulting (UK) Ltd, 2008). Long term impacts included disruption to cash flow and loss of income, psychological effects such as increased staff anxiety due to the effects of flooding, and higher insurance premiums. Table 5 presents a summary of the effects reported in five of the studies that examined the effects of flooding on businesses. However, it has to be noted that some of the effects reported in the studies have been adjusted to fit within a common framework, as the terminology used in the studies was often inconsistent. Whilst direct comparison of the percentage of businesses experiencing different impacts may not be appropriate due to factors such as differences in samples studied, terminology used, and context of the event etc., Table 5 enables the identification of some of the common impacts of flooding as well as a range of other impacts. As the table highlights, the effects ranged from direct effects such as premises being flooded, damage to premises/stocks and equipment to indirect effects such as those due to suppliers being affected by flooding and increases in insurance premiums.

Some of the impacts of flooding; for example property damage, spoilt stocks, temporary business closure, and travel difficulties, are clearly noticeable. However, some of the

impacts may not be. For an example, loss of paperwork due to flooding may have an impact on the recovery process later, as this may lead to delays in completing insurance claims, tracing orders, filing tax returns, etc (Pitt, 2008). As Whittle et al (2010) noted, flooding may cause indirect impacts; termed as “secondary flooding”, and such hidden damages of flooding may sometimes go unnoticed or may not be covered by insurance policies. Further, in addition to disrupting day-to-day business activities, flooding may have physical and psychological health effects including injuries and stress (Tapsell et al., 2002; Few et al., 2004; Penning-Rowse et al., 2005) to business owners, employees and customers. In the UK, employers are responsible for the health and safety of employees at work (HSE, 2008). Therefore, business owners may be responsible for any health impacts experienced by their employees due to the business being flooded.

Over and above the short term impacts, flooding presents other challenges to the victims, including that of recovery. Whittle et al (2010) discussed how flood recovery involves new and psychologically demanding work for residential occupants, as they often tend to oversee the repair and reinstatement works themselves. This could be particularly challenging for SME owners who work from home and owners who are local residents. That is, some SME owners are likely to be local residents, and thus, are affected both as a business owner and a local resident (Runyan, 2006; Tierney, 2007). The psychological stress associated with confronting unfamiliar work; e.g. flood damage, repair and reinstatement procedures, insurance claims, etc, can be substantial. Such psychological effects of flooding can often be more pronounced than the physical health effects (Tapsell et al, 2002).

Table 5 – Impacts of flooding on SMEs

Impacts	Woodman (2008)	EKOS consulting (UK) Ltd (2008)		Norrington & Underwood (2008)	BMG Research (2011)	Wedawatta et al (2012)
		Small businesses	Medium/ large			
Premises flooded	38%	80% - 100%	80% - 100%		5%	82%
Damage to premises (structural or otherwise)		80% - 100%	80% - 100%	38%	3%	66%
Damaged or lost stock		80% - 100%	80% - 100%			84%
Damaged or lost business equipment		60% - 80%	80% - 100%			61%
Move to temporary business premises					1%	34%
Loss of trade, production		60% - 80%	100%		10%	91%
Loss of income, reduced profit		80% - 100%	100%	13%		91%
Supplies to the business delayed (due to travel difficulties)		60% - 80%	80% - 100%		24%	73%
Suppliers affected by problems other than travel	27%				7%	
Deliveries to customers delayed (due to travel difficulties)		60% - 80%	60% - 80%		14%	75%
Travel difficulties for customers accessing the business				22%	27%	91%
Customers affected by problems other than travel difficulties					8%	89%
Staff unavailable for work	53%					
Travel difficulties for staff					25%	75%
Forced reduction of number of employees		60% - 80%	80% - 100%			
Other problems for staff, including anxiety		60% - 80%	80% - 100%		15%	
Decided to move premises		60% - 80%	80% - 100%			
Loss of power, telecommunications	18%				11%	86%
Loss of water supplies	11%					
Increase in costs						91%
Increase in insurance premiums		60% - 80%	80% - 100%			73%
Increase in trade/demand for services, positive impact	24%			8%		
Other adverse impacts					6%	64%

In addition to floods causing damages to businesses this in turn is likely to have an effect on wider communities and local economies. As Tierney (2007) discussed, impacts of disasters like flooding on businesses gives rise not only to direct business losses but also indirect losses and economic ripple effects. Damage to business premises and resultant temporary and permanent business closures may result in loss of jobs, negatively affecting employees' incomes and further hindering recovery efforts of local communities (Tierney, 2007). Such wider economic and social impacts are not normally accounted for in monetary terms; as opposed to direct physical damage in relation to flooding and other natural disasters.

Molinary and Handmer (2011) while differentiating between direct and indirect, tangible and intangible, and potential and actual damages by flooding noted that the evaluation of flood impacts tend to be limited to quantification of just direct tangible impacts. However, it has to be noted that such criticism is not limited to flooding alone, but seems to be common across other natural hazards. For example, Ciavola et al (2011) conducting a desktop study concluded that end-users tend to evaluate only the direct costs after storms.

Identification of the whole range of impacts of flooding on a business is important, as this could have a direct effect on the realisation of the true costs of flooding. Consequently, costs may be underestimated, negatively affecting any cost/benefit evaluation of flood protection measures, and thus limiting the uptake of such measures. For instance, Joseph et al (2011) emphasised that one of the reasons for the very low level of uptake of resilient reinstatement by property owners at risk of flooding was the lack of understanding of the costs and benefits of adopting such measures. It was concluded that

more needs to be done in order to encourage the uptake of resilient reinstatement by individual property owners (Joseph et al., 2011).

Table 5 above sought to address this issue by depicting the range of impacts that flooding can have on SMEs by presenting the impacts of flooding, reported in a number of recent studies, collectively. Whilst the percentage of businesses experiencing different impacts has varied across different studies, the table enables a range of impacts to be identified which may not have been identified in the findings of a single study. For example, the issue of unavailability of staff has only been reported in the study by Woodman (2008), whereas other studies have reported travel difficulties for staff (see Table 5).

2.5.1.2 Positive effects of EWEs on SMEs

Certain weather extremes may present businesses with new business opportunities. Extreme high temperatures such as the 2003 heatwave are expected to give rise to opportunities such as pavement cafes, fiestas, and increased sales of food and drink products (Metcalf and Jenkinson, 2005). Furthermore, consumer behaviour may change significantly due to their perceptions regarding weather changes. Changing markets, customer needs and investor expectations will present significant opportunities for businesses (Firth and Colley, 2006). Specific industries like flood defence and environmental services may be affected favourably due to EWEs. Industries like construction will also benefit from extreme weather due to the increased need for reconstruction and more robust structures (Dlugolecki, 2004). Webb et al (2002) discussed the ability of disasters to create windows of economic development, as disasters produce reconstruction booms and allow rapid community improvements to be made as opposed to gradual improvements. They further discussed how the

macroeconomic impacts of natural disaster events can have a long term positive effect on physical and human capital and productivity. Thus, SMEs will also benefit from such economic developments in the locality if they are in a position to capitalise the favourable conditions.

SMEs who successfully survive an EWE may experience increased customer loyalty, new customers, cost savings and additional sources of revenue (Holmes, 2006). They may also be able to enjoy enhanced attraction to potential employees and retention of existing staff by improving working conditions through climate proofing the work premises and ensuring that the premises are comfortable to work in (London Climate Change Partnership, 2005). Furthermore, a business resilient to potential EWEs will be able to enjoy reduced insurance premiums, secure investment opportunities and stakeholder reputation; all of which contribute towards business success.

Alesch et al (2001) found that the weaker small businesses tend to fail immediately following a disaster. They also reveal that many small firms on the edge of failure often collapse when the event strikes, even if they only suffer marginal damage. Unprofitable businesses may also be triggered by EWEs to consider moving or closing without even suffering any damage. From an economist's point of view, the failure of such firms will reduce further unnecessary costs to both the owners and society. Thus it can be regarded as an indirect benefit for business owners as they can avoid further losses.

Metcalf and Jenkinson (2005) identified a range of threats and opportunities, created by climate change, to businesses and classified them under seven major elements of a business. Some of the impacts identified in the report are related to EWEs. Table 6 shows

the EWE related impacts extracted from their report. Since the focus of their study is primarily on climate change, the contents of the table have been adjusted to better reflect the effects of EWEs. Most of the threats identified here have been discussed under the previous sub-heading. The opportunities identified by them reveal that the businesses that plan for probable EWEs and manage them successfully may enjoy positive business opportunities as opposed to negative impacts. Thus, the need for improving SMEs' resilience and adaptive capacities to EWEs so that they will be in a better position to cope with EWEs emerges.

Table 6 - Threats and opportunities to businesses arising from EWEs (Adapted from: Metcalf and Jenkinson, 2010)

Business area	Threats	Opportunities
Logistics	Vulnerability of supply of goods and services Disruption to utilities Vulnerability of transport and delivery systems	Maintaining supply and transport of goods and services through awareness and adaptation planning Creating secure systems of water storage and electricity generation on site
Finance	Difficulties in securing investment and/or insurance cover at reasonable cost Potential liabilities if EWE risk is not factored into long-term decisions	Reputation with all stakeholders Security for investment Reduced insurance premiums
Markets	Decreased demand for certain products Competitors' position enhanced by weather extremes	New products or modifications to existing products Become an early mover in response to changing markets
Process	Increased difficulties or entirely new problems due to extreme	Some aspects of production process or service delivery made easier especially

	temperatures, storms, and rain	due to temperature extremes
People	Threats to working conditions and travel arrangements Failure to attract or retain staff through reputation as poor employer	Improve working conditions and travel arrangements for staff Reputational opportunities as good employer
Premises	Vulnerability to flooding, storms and rain Challenge of coping with temperature extremes	Maintain, manage and re-furbish premises Optimise location of premises

2.5.2 Supply chain impacts of EWEs

The previous section identified disruptions related to the supply chain as one of the negative impacts associated with EWEs. In fact, previous studies (Norrington and Underwood, 2008; Woodman, 2008) have noted that supply chain related disruptions to be one of the most significant negative impacts of weather extremes on business organisations.

2.5.2.1 Vulnerability of supply chain

Supply chains face disruptions of various sorts (Snyder et al., 2006) and such disruptions are a common phenomenon (Svensson, 2000). Natural disasters, industrial disputes, terrorism (Christopher and Peck, 2004), dependence on a single supplier, supplier bankruptcy, terrorism, war, and political instability (Wilson, 2007) have all resulted in serious disruptions to supply chain activities. Recent events such as fuel protests in 2000, foot and mouth disease in 2001 (Peck, 2005) and the hot summer of 2003 in the UK, hurricanes Katrina and Rita (Snyder et al., 2006), September 11th terrorist attack (Sheffi and Rice, 2005) in the USA etc, have demonstrated that a disruption affecting an entity

anywhere in the supply chain can have a direct effect on a businesses' ability to continue operations, get finished goods to market or provide critical services to customers (Jüttner et al., 2003).

Snyder and Shen (2006) declare that supply chain disruptions can have significant cost implications (e.g. damage to facilities, inventory, electronic networks, and infrastructure) and subsequent losses due to downtime. Merchandise costs due to obsolescence, markdowns and stock-outs can be significant (Christopher and Lee, 2004). Moreover, a company that experiences a supply chain disruption can expect to face significant declines in sales growth, stock returns, shareholder wealth, and customer goodwill (Snyder and Shen, 2006). Therefore, it is critical to account for disruptions during the design of supply chain networks so that they perform well even after a disruption (Snyder et al., 2006).

2.5.2.2 Vulnerability of supply chain to EWEs

Extreme weather events like floods, hurricanes, storms, earthquakes etc can have significant effects on supply chains (Christopher and Peck, 2004; Kleindorfer and Saad, 2005). Whilst extremes affect both large firms and SMEs equally, they may affect SMEs disproportionately hard because of their size and limited resources (Finch, 2004). Therefore it has to be clearly identified what negative impacts might be levied upon businesses by the vulnerability of their supply chains to EWEs in order to improve their resilience.

Businesses may have to suffer, even without having a direct impact from an EWE, due to the vulnerability of supply chain, utilities and transport infrastructure (Burnham, 2006b).

If the supply chain of a particular business is affected by an EWE occurring elsewhere, it may affect the performance of the business, even though the particular business is not directly affected by the actual physical EWE. Therefore it has become a must for organisations to consider not only the direct impacts on their business but also the wider implications of EWEs. Metcalf and Jenkinson (2005) in their report “A changing climate for business” have presented a checklist (BACLIAT) for businesses to assess the effects of climate change on all aspects of a particular business. Of the six business areas considered on this checklist, logistics is given a top priority.

Vulnerability of supplies of goods and services (e.g. raw materials, components), disruption to utilities (electricity, water supply and sewage) and vulnerability of transport and delivery systems for goods and services are identified as major threats listed under logistics (Metcalf and Jenkinson, 2005). Table 7 shows some of the threats faced by different industry sectors as identified by Metcalf and Jenkinson (2005).

Table 7 - Threats faced by different industry sectors due to the vulnerability of supply chain
(Adapted from Metcalf and Jenkinson, 2005)

Industry sector	Threats
Agriculture	Disruption to transport infrastructure in short and long term, creating problems with raw materials in and goods out.
Building design and construction	Disruption of transport for site deliveries. Vulnerability of utilities
(Motor) Manufacturing	Supply chain interruptions to intensive production schedules, and resultant cost implications. Vulnerable transport systems, on which distribution depends for carrying high value products.
Financial services	Difficulty in dealing with claims due to prolonged extreme weather. Vulnerability of agents' operations due to impacts of weather

	extremes and unpredictable electricity supply etc
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Although the list identified is not comprehensive, it provides some idea about the disruptions that can be caused by EWEs to the supply chain of a business. All these disruptions can cause negative impacts on businesses as mentioned in the previous section (e.g. costs, losses due to down time, loss of customer goodwill etc). Therefore, it is important that businesses clearly identify these risks and take necessary remedial actions.

A publication by UKCIP (2003b) has proposed businesses ask themselves a list of questions in order to identify how vulnerable they are to climate change and how can they respond. Some of the questions drawn from that list are given below and which appear to help organisations to assess how vulnerable their supply chain is to EWEs.

- To what extent does the business rely on various transportation networks and can the risks be reduced through the use of alternative suppliers, transportation networks, etc?
- How might raw materials be affected and is there the need or scope to change the types of materials used?
- How might customer demand change and what impacts will this have on the products/services provided by the business?

In addition, Burnham (2006) proposes asking the following questions;

- How important are scheduled deliveries of supplies, uninterrupted power supply and clear roads in your business?
- If these things are threatened will you be able to deliver products on schedule?

If the organisations see themselves as vulnerable to disruptions in supply chain they may have to plan for remedial measures. The probabilities of EWEs such as flooding, hurricanes, earthquakes etc can be estimated from historical data (Sheffi and Rice, 2005). They can access information with regard to future projections of such weather extremes (e.g. Met Office, UKCIP publications, and various other sources), and prepare themselves using such historical data. Using such information, SMEs can assess the vulnerability of their supply chains based on the probable weather extremes that might affect them. A range of options are available for them to design resilient supply chain networks and their choice of approaches will depend on the financial resources available, the decision maker's risk preference, the type of network under consideration, and other factors (Snyder et al., 2006).

UKCIP summarises its experience of working with SMEs, with regard to climate change and EWEs, by identifying that "key risks are often related to markets and supply chains" for SMEs (2009). This issue is one of six key issues identified by UKCIP with regard to climate change adaptation for SMEs. The importance of the effects on the supply by EWEs was also highlighted in a workshop session (organised by the London Climate Change Partnership) and facilitated by the "Community Resilience to Extreme Weather – CREW" research team; of which this doctoral research forms a part, for representatives of SMEs and support organisations for SMEs. Furthermore, the need to have coping mechanisms to deal with supply chain disruptions was also highlighted by the SME representatives as it is often difficult for SMEs to control its supply chain due to their limited scale of operations. The other key issues raised was the need for specific and simple business

advice, continuous help in implementation, enhanced awareness and a medium to discuss supply chain related issues.

2.5.3 Coping strategies of SMEs

The previous section discussed how EWEs can affect SMEs, both negatively and positively. It is rational for them to implement various strategies to counteract the negative impacts of EWEs, which prevent and withhold the adverse impacts of EWEs on their business and also assist them in recovery. This section seeks to identify and evaluate various strategies that SMEs currently utilise to achieve the above.

2.5.3.1 Insurance

Insurance is one of the main mechanisms used by businesses to manage the financial consequences of risk, including the threat posed by natural hazards such as windstorms and floods (ABI, 2005). Property insurance and business interruption insurance are two types of insurance generally available for businesses to cover the risk of EWEs. However, AXA insurance (2008) reveals that 90% of small businesses are under-insured for their building insurance cover. A similar situation can be identified with regard to business interruption insurance. Citing AXA Insurance survey data, Crichton (2006) revealed that only about 64% of AXA's small business customers had insurance against business interruption or loss of earnings. Clemo (2008) reported a lower figure of 59%.

On one hand, insurance premiums that deal with losses due to weather acts are expected to increase in general due to the increased risk of EWEs (ABI, 2005). On the other hand, some of the risks may be seen as uninsurable by the insurance industry due to the significance of the threat. For instance, Crichton (2006) identified that the insurance

industry has already started to consider flooding as an uninsurable risk in a growing number of high risk areas. The UK insurance industry is quite unique with regard to cover against flooding as this is included in standard property insurance cover. The Association of British Insurers (ABI) in its revised statement of principles on the provision of flood insurance stated that its members will “continue to offer flood cover to existing domestic property and small business customers at significant risk of flooding providing the Environment Agency has announced plans and notified the ABI of its intention to reduce the risk for those customers to below significant within five years” until June 2013 (ABI, 2008a). If such measures are not implemented by the Environment Agency, flooding is likely to be considered an uninsurable risk for SMEs located in significant flood risk areas. Further, the ABI statement goes on to say that “the premiums charged and policy terms will reflect the level of risk presented”.

In addition to the cost of higher premiums this might cause another severe risk to SMEs. As premiums are high, they may tend to under-insure their assets, opt out of insurance or be denied insurance, leaving them vulnerable to further losses in the likelihood of an EWE, hence creating a vicious cycle. SMEs, in which the power of negotiation is smaller compared to large-scale organisations, may have to suffer losses because of these reasons. ABI identifies “financial inclusion to make insurance more available” as one of the objectives of their climate change adaptation strategy in the UK (ABI, 2009). Insurance may, increasingly, be seen as unaffordable by the SMEs, if such initiatives are not implemented.

Consequently, in a report published by the Chartered Insurance Institute, Crichton (2009) recommended that SMEs have to be provided with professional advice about the

importance of; 1. Adequate sums insured 2. Need for business interruption insurance especially to cover the cost of wages 3. Basic risk management procedures including business continuity plans, by the insurers and intermediaries, including banks.

2.5.3.2 Business continuity planning

McManus and Carr (2001) identified a business continuity plan as a “series of procedures to restore normal operations following a disaster – with maximum speed and minimal impact on operations” (McManus and Carr, 2001). Doughty (2008) saw it as an umbrella term which includes disaster recovery planning and business resumption planning. Business Continuity Planning (BCP) not only facilitates business survival but also influences societal resilience and effectiveness of recovery activities (Paton and Hill, 2006). According to Paton and Hill (2006), BCP is built around several key criteria; understanding what the business must achieve (its objectives), identifying the barriers or interruptions that may prevent their achievement, and determining how the business should continue to achieve its objectives amidst such interruptions.

However, 69% of UK small businesses surveyed by AXA Insurance had no form of business continuity plan (Crichton, 2006). According to the annual survey commissioned by the Chartered Management Institute (see Table 8), the percentage of small businesses with a business continuity plan varied between 25% - 34% since 2007. In medium sized businesses this figure was 42% - 49%. A significant difference can be identified between smaller businesses and larger ones when it comes to having a business continuity plan. This can partly be due to the resource constraints pertinent to SMEs. BCP is a process that has to be developed individually for a specific business (Paton and Hill, 2006). This requires resources; human, technical, as well as financial. For SMEs, especially for micro

and small businesses, such resources may not be readily available to enable them to develop and maintain a business continuity plan. Furthermore, it is important that businesses do consider the risk of EWEs in their BCP, as they may tend to underestimate the EWE risk even if such a plan is available for their business. Further, Jones and Ingirige (2008) argued that BCPs generally tend to focus on individual events affecting a business, rather than the wider scale implications of such events. It is argued that generally BCPs do not consider the broader implications of EWEs; for instance, effects on and from supply chain partners, temporary working solutions etc, and that these are missing from business continuity plans of most SMEs in the UK. Therefore, if the SMEs are to benefit from BCP, they will not only have to consider possible risks of EWEs, but will also have to undertake a much broader view to consider the wider impacts of EWEs.

Table 8 - Percentage of surveyed organisations with a business continuity plan

Year	Small businesses (0-49 employees)		Medium businesses (50 – 249 employees)	Large businesses (over 250 employees)
2007	34%		42%	62%
2008	33%		46%	62%
2009	25%		49%	64%
2010	29%		49%	65%
	Micro (0-9 employees)	Small (10-49 employees)		
2011	23%	54%	58%	71%
2012	31%	48%	61%	74%

Source: Woodman (2007; 2008), Woodman and Kumar (2009), Woodman and Hutchings (2010; 2011), Pearson and Woodman (2012)

2.5.3.3 Property-level protection measures

Property level protection measures are considered important, especially in relation to the risk of flooding. Flood related property level protection measures are mainly categorised into two types; resilience measures and resistance measures. Whilst resistant measures aim to prevent floodwaters from entering business premises, resilience measures aim to minimise the impact of floodwaters on business premises (Bowker et al., 2007). One of the recommendations of the Pitt Review following the 2007 floods in the UK (2008) is to promote business continuity by encouraging the uptake of property level flood resistance and resilience measures by businesses.

Although property level protection measures generally tend to focus on flooding, these measures are important against other EWEs as well. For instance, heat waves can affect production processes and internal environments of business premises making employees less able to work and thereby affecting productivity. Property level protection measures such as insulation, improved ventilation and cooling may be required to counteract such impacts. The National Health Service in its heat wave plan for England (1989) recommends increasing shading around and insulation of buildings as property level coping strategies against heat waves and extreme heat.

Generally, snowfall related property level protection measures tend to convey images of measures against low temperatures inside buildings. However, ABI (2010) reports that insurers paid over £60 million to businesses for property damage due to heavy snowfall in 2010. Most of the claims had involved roof damage due to heavy snowfall. This suggests that property level protection measures such as roofs with a higher load bearing capacity may need to be considered in relation to heavy snowfall. Potential increase in future wind

speeds also suggests that development of more robust roof designs is important (UKCIP, 2003a).

However, property level protection measures often involve capital costs and this may discourage their adoption by SMEs. The economic aspects of investing in property level protection measures may also discourage their adoption. For example, according to the Environment Agency (Thurston et al., 2008), property level flood resistance measures are seen as economically beneficial for businesses if the risk of flooding is greater than 4% (25 year return period) only. The risk has to be greater than 10% (10 year return period) for property level resilience measures to be economically beneficial.

2.5.3.4 Other coping strategies

Crichton (2009) identified relocation, temporary premises, obtaining professional advice to manage the risk posed by EWEs as some of the coping strategies available for businesses. However, he claimed that currently the level of and drive for implementation of such strategies was minimal. Business Link Northwest (2010) recommended businesses to consider managing their suppliers and introducing working from home for employees as possible strategies to counteract the disruptions caused by extreme weather. Their recommendations include consideration of alternative premises (to be used during and after the event), minimising dependence on individual staff (by encouraging other employees to gain good understanding of critical processes), and also stock piling critical supplies and materials. Co-operation with other businesses is a key strategy proposed by AXA Insurance (2008). They suggest small businesses utilise their existing networks effectively and share information, alternative suppliers and premises etc., in an event of disruption. Preparing for IT failure such as having a backup for critical business

information is also often recommended for businesses. Although these strategies sound ad-hoc and fragmented they are some of the practical strategies available for businesses to minimise their risk to EWE related disruptions. However, it is important that such actions form part of a comprehensive strategy rather than spontaneous responses. This requires businesses to conduct some variant of a risk assessment and to identify how best to deal with the different issues identified.

Many of the sources of advice available for businesses with regard to extreme weather encourage businesses to conduct a risk assessment in order to identify the risk of EWEs to their businesses and how the individual business activities could be affected. Although the complexity and comprehensiveness of the risk assessment exercises suggested varies, such an assessment is considered fundamental in making business decisions with regard to extreme weather conditions. For instance, Business Areas Climate Impacts Assessment Tool (BACLIAT) developed by the UK Climate Impacts Programme (UKCIP) assists businesses to assess the risk of changing climatic conditions, including extreme weather, to their businesses. Such an assessment could be conducted as part of BCP or could well lead to a business continuity plan. However, it is questionable as to what extent a generic SME is capable of conducting such an assessment on its own.

Berkhout et al (2006) observed four alternative adaptation strategies among businesses with regard to climate change and extreme weather. These are “wait and see”, “risk assessment and options appraisal”, “bearing and managing risks”, and “sharing and shifting risks”. “Wait and see” is a deferral strategy, where the organisation will delay adaptation based on scepticism or uncertainty related to climate change. Organisations assess the different adaptation options available in “risk assessment and options

appraisal". "Bearing and managing risks" is a strategy where the risks and opportunities arising from climate change are managed using existing organisational resources and capabilities. In "sharing and shifting risks", organisations attempt to transfer risks to external parties via approaches such as obtaining insurance. Berkhout et al (2006) identified core competencies, core business, dynamic capabilities, and organisational culture as the factors that affect organisations' approach towards an adaptation strategy. Yoshida and Deyle (2005) classified factors affecting small business hazard mitigation into 4 main categories; characteristics of the businesses and the buildings within which they are located, hazards knowledge and experience of business owners and managers, access to technical knowledge about mitigation alternatives, and perceptions of the costs and benefits of alternative mitigation measures. Their empirical research identified that access to expertise, type of business, and perceived exposure of the business location to natural hazards as major factors affecting mitigation. Although the term "mitigation" was used in the study of Yoshida and Deyle (2005), the term has been used as a synonym for the term adaptation, rather than to mean mitigation as used in climate change literature.

2.6 EWEs and construction SMEs

Increasing risk of EWEs was addressed in Section 2.2. Discussions in Sections 2.3 to 2.5 established the case for focusing on SMEs, due to the significant impacts that such EWEs could have on SMEs, their vulnerability and lack of preparedness. Accordingly, the need for further studies addressing the resilience of SMEs to EWEs was established. This section seeks to establish the need for specifically focusing on construction SMEs. Accordingly, this section seeks to discuss the risk of EWEs specifically from a construction SME perspective. Firstly, the importance of SMEs to the construction industry is examined

and, secondly, the vulnerability of construction SMEs and their response to EWEs are then discussed. The case for focusing on construction SMEs is then synthesised in Section 2.6.4.

2.6.1 SMEs in construction

Construction industry plays a significant role in the economy of a country. In the UK, the industry contributes to over 7% of the gross domestic product, and account for over £110billion of economic activity (Cabinet Office, 2011). The UK government recognises that a successful construction industry as vital for sustainable growth, as the industry is responsible for the delivery and maintenance of residential and commercial properties, and economic and social infrastructure that support the whole economy of the country (HM Treasury, 2011).

SMEs dominate the construction industries of many countries. As a result, as a community, they tend to contribute significantly to its development and growth. In the UK too, SMEs represent a significant majority of enterprises in the construction industry. According to statistics, over 0.9million SMEs operate in the construction industry in comparison to approximately 300 large enterprises (BIS, 2012). The construction industry is characterised by the presence of a large number of self-employed or sole-proprietorships, exceeding 755,000 and amounting to 83% of the total number of enterprises (BIS, 2012). Even when the number of enterprises with employees is considered, over 99% fall to the category of SMEs, highlighting the significant presence of SMEs in the industry. In the UK economy, construction is one of the industry sectors where SMEs contribute significantly to the employment statistics and revenue generated. As Table 9 depicts, SMEs generate around 85% of employment and around 70% of

revenue in the industry, indicating the importance of SMEs to the construction industry. Along with sectors like agriculture, education, and health and social work, construction is a sector in which the contribution of SMEs is significantly high in terms of employment and generation of revenue. Construction, based on these figures, can be identified as an industry which is largely dominated by SMEs as opposed to sectors like mining and quarrying, financial intermediation, transport, and manufacturing in which the large organisations contribute to the bigger share of employment and revenue generation. Thus, SMEs are vitally important to the successful operation of the UK construction industry and the cumulative effect of their failure could have a significant impact on the whole industry.

The importance of the SME sector in the construction industry is often undervalued (Dainty et al., 2001), perhaps due to the small scale of their individual contribution. Although the individual impact of SMEs are small, the cumulative impact is highly significant (International Institute for Sustainable Development, 2004). The importance of SMEs can be recognised in many facets in addition to the numbers employed and revenue generated. For instance, although SMEs are much less likely to undertake expensive research-based breakthrough innovations (Curran and Blackburn, 2001), they play a crucial role in the innovation process, in particular by generating more radical innovation (European Commission, 2008). As many SMEs serve a specific niche market where they marginally differentiate their products or services to successfully compete and survive, it is likely for them to actively engage in continuous innovation. As SMEs constitute the bulk portion of construction sector businesses such innovation is likely to influence the innovation-led performance of the whole industry (Sexton and Barrett, 2003b).

In providing the construction industry perspective to the Committee of Inquiry on Small Firms (Bolton, 1971), Hilderbrandt (1971) highlighted four main characteristics that suggest the importance of small firms to the construction industry. These are; flexibility, localised demand, good labour relations, and low capital requirement for entry (Hilderbrandt, 1971). Whilst a small firm was considered a business when employing less than 25, these characteristics can also be related to SMEs.

Table 9 - Employment and turnover generation by SMEs in the UK construction industry

Year	Employment	Turnover
2008	84.2%	70.9%
2009	85.1%	70.2%
2010	84.1%	72.1%
2011	84.5%	72.4%
2012	85.1%	72.9%

Adapted from BIS (2009a; 2010a; 2011; 2012)

2.6.2 Vulnerability of construction SMEs to EWEs

EWEs can have both direct and indirect effects on the construction sector and those associated with it. Direct effects include disruption to site works as a consequence of the EWE itself (e.g. the site might be flooded); indirect effects include disruption to site works as a consequence of the secondary effects of an extreme weather event (e.g. due to disruptions to deliveries and utility supplies through the supply chain) (Metcalf et al., 2009). This distinction is shown in Figure 1. As a consequence of the UK construction industry being dominated by the presence of a significant number of SMEs, a supply chain consisting of a number of organisations is likely to deliver major projects (Stewart et al., 2004). In the construction sector, the network of supply chain members can often be

extremely complex, particularly on a larger project where the number of separate supplying organisations will run into hundreds, if not thousands (Briscoe et al., 2001). Citing a number of sources, Sexton and Barrett (2003b) avow that the industry is generally driven by single and unique projects, each creating and disbanding project teams made up of varying combinations of large and small firms from across the supply chain spectrum. Thus, construction SMEs are likely to be exposed to a range of supply chain related impacts associated with EWEs, increasing their vulnerability to such events.

However, whilst construction industry SMEs have been aware for many years of the direct affects that adverse weather could have on their operations, and indeed have developed project programming strategies to deal with such eventualities, there is less evidence to suggest that they are prepared for extreme weather events as a consequence of climate change or have considered in detail the indirect impacts to their operations of disruptions to their supply chain (Berkhout et al., 2004). This, when combined with the fact that construction sector SMEs were found to be the least prepared in terms of business continuity planning (only about 20% of construction sector SMEs had a plan to deal with business interruption compared to the other industry sectors surveyed; manufacturing, retail, business/financial services, transport, and land based SMEs) (Norrington and Underwood, 2008) leaves them vulnerable to the consequences of an extreme weather event. For example, a survey of businesses operating in the Cumbria region found that a majority of businesses that have ceased business following extreme weather events in 2009 and 2010 were found to be construction SMEs (Wiseman and Parry, 2011). 74% of businesses that have ceased trading were from construction, all of whom falling into the category of SMEs.

From a construction SME perspective, their resilience to EWEs is likely to be focused around their projects, which is the core of their practice. This was observed by Hertin et al (2003), where it was noted that construction organisations were mainly concerned about the impact of weather events on construction processes and how weather extremes can affect their ability to deliver the projects within the cost and time constraints. Therefore, whilst the focus is mainly on construction SMEs at the organisational level, how construction SMEs respond to EWEs on their construction projects is also investigated in this study. However, evidence that identifies construction SMEs as being in the majority of businesses who ceased to function following EWEs that affected the Cumbrian region in 2009 – 2010, suggests that organisational level response to EWEs is also important (Wiseman and Parry, 2011). This suggests that EWEs have critically affected the business continuity of construction SMEs, necessitating responses to EWEs focusing both on construction projects (process) as well as their organisations, in order to enhance their long term survival amidst the increasing risk of EWEs.

In essence, construction SMEs do not appear to recognise the seriousness of current extreme weather events or to have appropriate risk assessment frameworks in place to assess their vulnerability, resilience and adaptive capacity to more extreme events that may occur as a consequence of climate change. It should be noted that such criticisms are not restricted to construction industry SMEs but have been observed across the range of organisations exposed to a range of extreme weather events and other natural hazards (Tierney and Dahlhamer, 1996; Alesch et al., 2001; Yoshida and Deyle, 2005; Crichton, 2006; Dlugolecki, 2008).

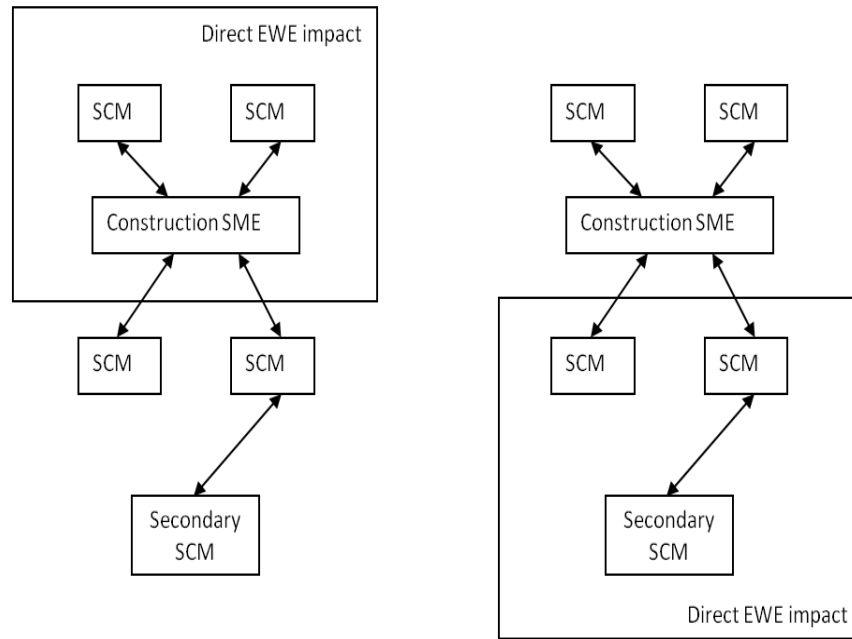


Figure 1 - Relationship of Construction SMEs and supply chain members (SCM) in relation to EWEs - Adapted from Zhang et al (2009)

2.6.3 Construction SME response to EWEs

In an examination of the attitudes of companies involved in the construction industry, Berkhout et al (2004) found that organisations respond to signals about the impact that an EWE may have on their operations in the context of their own, and their competitors performance. If a threat/opportunity is perceived, existing solutions to address any impacts will be applied, and if successful, the business will continue as usual. It was pointed out that investing in new solutions to the problems and seeking evidence to measure their success will only be done if their initial interventions are unsuccessful. Based on this theory Berkhout et al (2004) developed a 4 stage decision-making framework based around: risk and opportunity analysis; strategy setting; implementation; and integration. However, when evaluating the model against climate change scenarios Berkhout et al (2004) found that:

- Organisations found it difficult to recognise and interpret climate change stimuli.

- Trial and error experimentation with existing operating procedures were unlikely to yield satisfactory results due to the weaknesses and ambiguities associated with climate change stimuli.
- Organisations found it difficult to assess the advantages and disadvantages of alternative adaptation strategies.
- Organisations found it difficult to directly measure the impact that the adaptation has had on organisational value.

On a somewhat similar note to the 4-stage decision making model developed by Berkhout et al (2004), the protective action decision model developed by Lindell and Perry (2012) recognises that the decision making process, with regard to addressing disaster risks, contains of a number of stages. Accordingly, psychological processes containing three sets of activities—(i) pre-decisional processes; (ii) core perceptions of the environmental threat, alternative protective actions, and social stakeholders; and (iii) protective action decision making, were identified as the different stages of decision making. It was stated that decision making regarding implementing protective actions / coping strategies will commence once the pre-decisional processes are completed and three key core perceptions are activated. The stage of decision making was seen to consist of a number of stages; risk identification, risk assessment, protective action search, protective action assessment, and protective action implementation. The model by Lindell and Perry (2012) suggests the complex nature of decision making with regard to implementing coping strategies against risks such as EWEs. The inherent characteristics of SMEs, such as lack of resources and expertise, make it difficult for SMEs to go through the different stages of decision making and address the risk of EWEs within their business planning.

Similar findings to the above have been identified by other authors who found that: a lack of forward planning, lack of capital for recovery, ineffectual interactions with national agencies, infra-structure problems (Runyan, 2006); individual attitudes and organisational culture (Petts et al., 1998); access to expertise, perceived exposure to risk (Yoshida and Deyle, 2005); lack of integration of the construction sector in disaster risk management in the UK (Bosher et al., 2007a); and the relatively low importance assigned to climate change and EWEs by the construction sector (Harty et al., 2007), all contributing to a general inertia amongst SMEs to consider resilience to EWEs.

Thus, this raises questions as to whether current approaches to business continuity/risk management is capable of delivering increased resilience and enhanced adaptive capacity in response to vulnerabilities associated with EWEs. Given the predicted increase in the intensity and frequency of EWEs (Stern, 2007), the construction sector needs a new way of viewing the risks and developing business contingency plans, both from a business survival perspective and as a major stakeholder to wider community recovery following an EWE. Indeed, the construction sector needs to recognise that it has a significant role to play in delivering a resilient built environment. Further, Mullins and Soetanto (2011) discussed the responsibility that SMEs have towards the resilience of other community groups such as households and policy makers and on the resilience of the community as a whole. The responsibility of construction SMEs can be argued to be even greater due to their role in delivering a resilient built environment. This requires a greater degree of organisational resilience, awareness, and proactive response of construction SMEs against EWEs.

2.6.4 Case for investigating construction SME resilience to EWEs

It can be argued that one of the reasons that contributes towards the increased vulnerability of the construction sector to the adverse effects of EWEs is the dominance of SMEs within the industry. As discussed in previous sections (See section 2.5), SMEs are considerably more vulnerable to the effects of EWEs than large businesses and are less likely to be resilient against such events. Dominance of a vulnerable cohort of businesses within an industry that is, to a large extent, weather dependent, has created EWE resilience in SMEs a matter of significance to the industry in the wake of increasing risk and occurrences of EWEs.

Whilst construction SMEs have been aware of the direct impact of adverse weather on their operations and have even developed strategies to deal with such events, there is less evidence to suggest that they are prepared for the impact of EWEs; especially at the organisational level, or have not considered in detail the indirect impact on their operations arising from disruptions to their supply chain. Although construction has been perceived as a sector significantly vulnerable to the impacts of EWEs, the issues with regard to vulnerability of construction SMEs to EWEs, their coping capacity and coping mechanisms have only been subjected to limited in-depth academic research. It can be argued that this lack of comprehensive understanding has also contributed towards the inertia among construction SMEs in increasing their resilience to EWEs. As for the extant literature on their response to EWEs and the impact of recent EWEs on their businesses, construction SMEs do not appear to have appropriate decision making frameworks in place to assess their resilience to increased intensity and frequency of EWEs. To address

this issue a novel approach to assessing their resilience to EWEs and the impact that possible coping strategies could have on business resilience is required.

From the previous discussions, it is evident that being resilient to EWEs will enable construction SMEs to minimise negative impacts of such events. More importantly, being resilient will allow businesses to realise and capture business opportunities presented by EWEs. For instance, construction SMEs can benefit from extreme weather due to the increased need for reconstruction and more robust structures (Dlugolecki, 2004). EWEs could also create new opportunities for SMEs in construction such as to constructing flood defences and enhancing existing defences (Soetanto et al., 2006). More importantly, as a major stakeholder in the UK construction industry, construction SMEs have to play a significant role in achieving a resilient built environment. As discussed by Boshier et al (2007a; 2007b) and Haigh and Amaratunga (2010), the role of construction organisations, professionals and other stakeholders involved in the industry are critically important in realising a resilient built environment amidst the predicted increase of EWEs. Given the vital role of SMEs in the construction industry, it is not difficult to speculate on their importance in this. Being a resilient enterprise which considers and acts upon the risk of EWEs the process of learning lessons from the past and achieving a resilient built environment will be enhanced and vice versa.

In order to achieve the above; i.e. to enhance the resilience of construction SMEs, a method of identifying their vulnerability to such events, capabilities required, and strategies that have to be implemented, is required. Inevitably, such a method has to take into account the characteristics and requirements of construction SMEs. For instance, Sexton et al (2006) stated that construction SMEs are likely to absorb measures

which can contribute to their businesses quickly and tangibly. According to them, SMEs will prefer measures which can be readily aligned with competencies and capabilities already available or can be acquired through their existing business networks and lie within their comfort zones.

This research is developed to address the above mentioned gap in the knowledge, identifying the growing need for improving the resilience of construction SMEs and their supply chain to the effects of EWEs. Therefore, this research sought to investigate the resilience of construction SMEs to EWEs and to develop a decision making framework that can be used by them to assess their resilience to EWEs.

2.7 Resilience to EWEs

The increasing risk of EWEs, significant vulnerability of SMEs to their impacts, and the inherent vulnerability of the construction industry and the stakeholders operating within the industry; construction SMEs in particular, to the impacts of EWEs were addressed within the previous discussions. These discussions also formed the basis for the study by identifying the need for further studies to look into the resilience of construction SMEs to EWEs. Within this section the concept of resilience and related terminology is discussed. This discussion leads to a conceptual framework depicting the theoretical basis for how it is proposed to achieve increased resilience to EWEs within construction SMEs.

2.7.1 Concept of Resilience

The term “resilience” is largely attributed to ecological systems and has originated within the body of ecology literature (Holling, 1973; Adger, 2000a; Gallopín, 2006). The term has been subsequently applied in a range of subject localities such as psychology, materials

sciences, economics, environmental studies and social sciences (Adger, 2000a; McDaniel et al., 2008). The discussion here is limited to the concept of resilience from a social sciences perspective addressing hazards, climate change and related disciplines.

Adger (2000a) discussed ecological resilience from two perspectives; (a) the amount of disturbances a system can absorb before it changes its structure by changing the variables and processes that control its behaviour, and (b) speed of recovery following a disturbance. Consequently, social resilience was defined as “the ability of communities to withstand external shocks to their social infrastructure” (Adger, 2000a p361). On a similar note, Carpenter et al (2001) defined resilience as “the magnitude of disturbance that can be tolerated before a socio ecological system moves to a different region of state space controlled by a different set of processes”. Both these definitions infer resistance to disturbances as a key criterion of resilience. However, Carpenter et al (2001) emphasised that resilience has the characteristics of; (a) the amount of change the system can undergo whilst retaining the same structure and function, (b) the degree to which the system is capable of self-organisation, and (c) the degree to which the system can build the capacity to learn and adapt. Many of the resilience definitions have used some variant of these characteristics in arriving at a definition for resilience.

The International Strategy for Disaster Reduction - ISDR (2009) identified resilience as “the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions”. According to the Intergovernmental Panel on Climate Change (2007), resilience is “the ability of a social or ecological system to absorb disturbances

while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change". Whilst the latter definition highlights a system's ability for absorbing disruptions, the former definition also acknowledges that disruptions can occur and thus highlights the ability to recover from a disruption as well. Paton (2007) defined resilience as the "capacity of a community, its members and the systems that facilitate its normal activities to adapt in ways that maintain functional relationships in the presence of significant disturbances". It was argued that resilience has to entail adaptive capacity as it could be untenable to return to the pre event conditions due to the changes that might occur to the environment (physical, social as well as psychological) following a hazard event. Paton's definition highlights an important aspect related to hazards, which is different to climate/environmental change.

For the purpose of this research a working terminology developed for the CREW research project will be used. Accordingly, resilience is defined as "the ability to prevent, withstand, recover from and learn from the impacts of extreme weather hazards" (Hallet, 2013). This definition goes beyond the ISDR and IPCC definitions and recognises the importance of learning from EWEs once experienced, and incorporating the lessons learnt in future preparedness, as highlighted by Carpenter et al (2001).

Various researchers have attempted to represent resilience from a hazard perspective focusing on different units (See Table 10). For instance, Cutter et al (2008) have looked at community resilience from a natural hazards perspective. Cutter et al in their model recognised that, whilst there is a growing body of research focussing on defining the dimensions of community resilience, little attention has been paid to the development of

consistent factors or standard metrics to quantify community resilience (Jones and Few, 2009). They have addressed this shortcoming by identifying a set of variables to measure community resilience. According to the Disaster Resilience of Place (DROP) model developed by Cutter et al (2008), “the total hazard or disaster impact is a cumulative effect (or sum) of the antecedent conditions, event characteristics, and coping responses”. The overall impact will be moderated by the absorptive capacity of the community being affected. Cutter et al (2008) identified absorptive capacity as “the ability of the community to absorb event impacts using predetermined coping responses”.

Table 10 - Frameworks on Resilience from a hazard perspective

Source	Context	Focusing on	Components of resilience
Bruneau et al. (2003) Tierney and Bruneau (2007)	Seismic, Disasters	Communities, Infrastructure systems	Robustness Redundancy Resourcefulness Rapidity
Paton (2007)	Natural hazards	Societal resilience	Personal - Critical awareness, Self-efficacy, Sense of community, Outcome expectancy, Coping, Resources Community – Collective efficacy, Participation, Commitment, Information exchange, Social support, Decision making, Resources Institutional – Empowerment, Trust, Resources, Mechanisms for assisting community, Problem solving
McManus et al. (2007)	Disasters	Organisational resilience	Situation awareness – Roles and responsibilities, Understanding of hazards and consequences, Connectivity awareness, Insurance awareness,

			Recovery priorities Management of keystone vulnerabilities – Planning strategies, Participation in exercises, Capability and capacity of internal and external resources, Organisational connectivity Adaptive capacity – Silo mentality, Communications and relationships, Strategic vision and outcome expectancy, Information and knowledge, Leadership, management and government structure
Cutter et al (2008)	Natural disasters	Community resilience	Antecedent conditions Disaster severity Time between hazard events Influences from exogenous factors
McDaniels et al (2008)	Extreme events	Infrastructure systems	Robustness(the extent of system function that is maintained) Rapidly (the time required to return to full system operations and productivity)

2.7.2 Organisational resilience

Somers (2009) discussed the broad range of resilience definitions found in organisational theory, ranging from definitions focussing on passive approaches such as bouncing back from disruptive events and absorbing disruptions to active approaches aimed at improving capacity to cope with disruptive events. Many of the recent definitions of organisational resilience embrace the notion of active resilience in a dynamic environment. McManus et al (2007) identified resilience, in an organisational context, as a function of an organisation's situation awareness, management of keystone vulnerabilities, and adaptive capacity in a complex, dynamic and interconnected environment. McManus et al (2007), in their framework developed to assess and analyse

organisational resilience, have identified 15 key resilience indicators which represent key resilience issues in an organisation. These indicators are grouped under three main interrelated categories; situation awareness, management of keystone vulnerabilities, and adaptive capacity. Linnenluecke and Griffiths (2010) argued that capabilities that enable organisations to prepare for EWEs and different response and operational strategies to minimise the impact and to facilitate recovery and reorganisation as key to achieving organisational resilience. Accordingly, organisational capabilities and strategies were thought to be key elements of resilience.

Elwood (2009) declared that the concept of resilience is broader than risk management or business continuity management. It was elaborated that resilience incorporates the notion of a living organism, able to adapt and respond to changing environments and overcome adversity. The definition of resilience adapted for this research; “the ability to prevent, withstand, recover from and learn from the impacts of extreme weather hazards”, entails a similar viewpoint. Indeed, learning lessons from different hazard events and embracing the lessons learnt are considered to be key in enhancing organisational resilience (Berkhout et al., 2004; Crichton et al., 2009; Linnenluecke and Griffiths, 2010).

Adaptation and adaptive capacity as well as vulnerability are some of the concepts that relate to resilience. There appears to be considerable debate over the meaning of these terms as well as their relationship (Gallopín, 2006; Smit and Wandel, 2006; Cutter et al., 2008). For instance, Kelly and Adger’s (2000) definition of vulnerability closely resembles the resilience definition of ISDR and ICCR discussed above. Different viewpoints exist concerning the relationship between resilience and vulnerability, where resilience is seen

as a component of vulnerability (Smit and Wandel, 2006) and vulnerability as a component of resilience (McManus et al., 2007). Similarly, adaptive capacity is seen as an inherent component of resilience (Paton, 2007), and vice versa (Adger, 2006). Similar discrepancy can be identified between adaptation and vulnerability, whereas it is thought that adaptation is facilitated by reducing vulnerability (Kelly and Adger, 2000), and vice versa; adaptation facilitating reduced vulnerability (Smit and Wandel, 2006). Cutter et al (2008) discussed and graphically presented different relationships observable between these terms, specifically in hazards and environmental/climate change literature (See Figure 2). In this research these terms are thought to be inter-related but separate concepts having common as well as exclusive content.

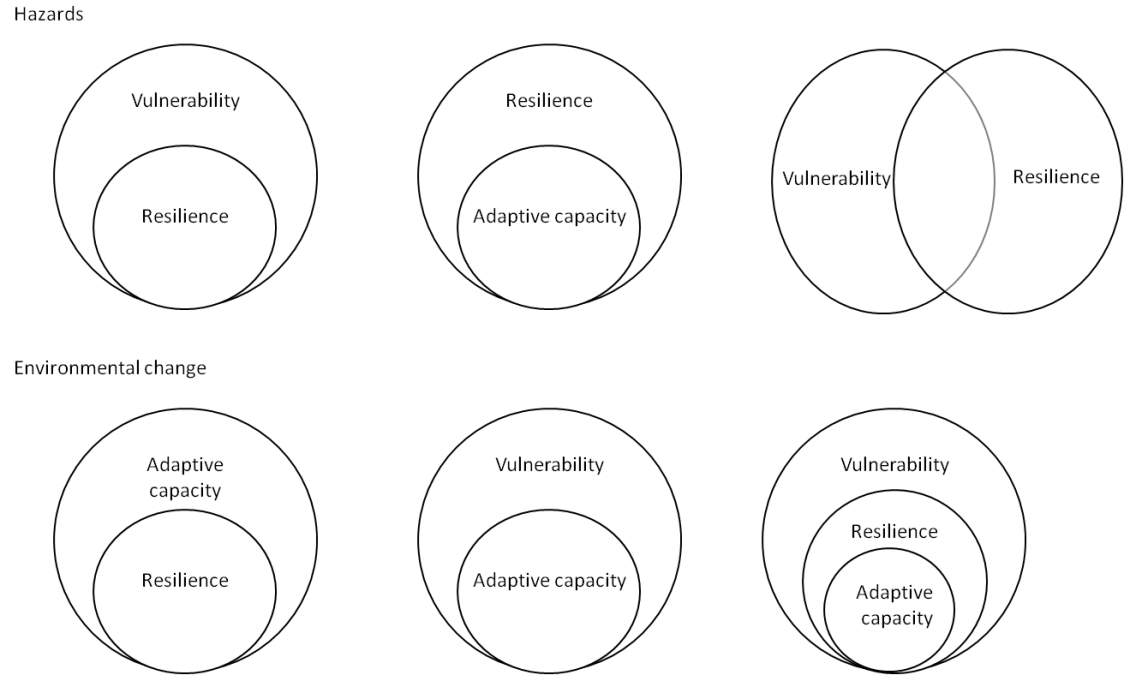


Figure 2 - Linkages between resilience, vulnerability and adaptive capacity (Cutter et al, 2008)

2.7.3 Vulnerability and adaptation

2.7.3.1 Vulnerability

Although the concept of vulnerability has been used in different research traditions, a proper agreement over its meaning is still to be arrived at (Gallopín, 2006). The Intergovernmental Panel on Climate Change (IPCC) defined vulnerability as “the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes” (Parry et al., 2007). It further identified vulnerability as “a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity”. The International Strategy for disaster Reduction (UNISDR, 2009) defined vulnerability as “the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard”. These two definitions deal with climate change and natural disasters respectively, but not specifically in an EWE context.

Vulnerability, in this research, is identified as “the characteristics and circumstances of humans and human systems that determine how susceptible they are to the impact of EW hazards” (Hallet, 2013). Thus, in a SME context, vulnerability can be identified as “the characteristics and circumstances of SMEs that determine how susceptible they are to the impact of EW hazards”. In a broader term, it relates to the extent to which a particular SME can be harmed by a hazard.

2.7.3.2 Adaptation and adaptive capacity

Adger (2000b) defined institutional adaptation as “the net outcome of the evolution of institutions within the wider social environment along with institutional inertia”. The term institutions here includes “both socialised ways of interacting and underlying worldviews,

as well as structures and organisations that influence resource allocation” (Adger, 2000b). Adger (2000b) argued that the adaptation of organisations can be observed by actual resource allocations, processes of decision making and non decision making, and changing perceptions of vulnerability. Bleda and Shackley (2008) identified adaptation as “the response to the impacts of both ‘physical’ events (precipitation, floods, droughts, etc.) and to changes in the organisation's institutional environment brought about by climate change (e.g. changes in mitigation policies, in media trends, or in the scientific community's perspective on climate change)”. The definition attempts to address adaptation of organisations to climate change impacts both in their physical and institutional environments. Bleda and Shackley (2008) identified belief in climate change and the risks involved as major factors affecting organisational adaptation. In this research adaptation is identified as “initiatives and measures to reduce the vulnerability of humans and human systems to actual or expected climate change effects, including increases in the intensity or frequency of EWEs” (Hallet, 2013).

AEA Technology (2009) identified adaptive capacity as the “ability of an individual, group or sector to adjust to climatic changes, curb potential damage, cope with the consequences of impacts, or profit from new opportunities”. Hertin et al (2003) identified that adaptive capacity in an organisation is related to an awareness of the need to adapt, ability to make decisions regarding which measures to implement, and capacity to implement and control the process of adaptation. They considered adaptive capacity to be a result of the internal capabilities and external relationships of an organisation. In this research, adaptive capacity is considered to be “the ability of a system to implement effective adaptation measures” (CREW Working Terminology).

2.7.3.3 Coping capacity and coping strategies

Whilst adaptation and adaptive capacity are terms that appear prominently in climate change literature, hazard literature seems to use the terms coping and coping capacity to denote similar concepts. As discussed by Brooks et al (2005), vulnerability to hazards related to weather extremes that may occur in the immediate future is more related to existing short-term coping capacity rather than the ability to pursue long-term adaptation strategies. Further, Gallopín (2006) pointed out that coping capacity is used to denote short term capacity or the ability to survive, whereas adaptive capacity is used to denote long term adjustments. Considering the nature of EWEs and the shorter strategic horizons of SMEs the term coping capacity, in relation to resilience, will be used in this research.

UNISDR (2009) defined coping capacity as “the ability of people, organisations and systems, using available skills and resources, to face and manage adverse conditions, emergencies or disasters”. This involves resource management to cope up with hazards before, during and after the occurrence of a hazard. Coping capacity, in this research, is defined as “the ability of people or organisations to limit adverse consequences of EW hazards, using available resources and capabilities” (Hallet, 2013). From a SME context, this can be defined as “the ability of a SME to limit adverse consequences of EW hazards, using available resources and capabilities”. This definition is in line with the definition of resilience applicable to this research; however it depicts a rather reactive approach whereas the resilience definition also embraces a proactive approach. This definition, like that of ISDR, also highlights the importance of management of resources and abilities, in this case available to SMEs. Coping strategies are defined as “actions that increase the ability to prevent, tolerate and/or recover from the impacts of EWEs” (Hallet, 2013) in this

research. These may include both physical and non-physical actions such as obtaining business interruption insurance, business continuity planning, flood defences etc.

2.8 Forming the research problem

Following the review of literature, this section seeks to revisit the research problem identified in Section 1.2. Reviewing the literature on the risk of EWEs (see Section 2.2) revealed that the risk of EWEs was already considerable in the UK and elsewhere and was having considerable impact on the communities affected. Further, future projections suggested that the risk of EWEs is likely to further increase under changing climatic conditions. SMEs in general were found to be noticeably vulnerable to the impacts of such events (see Section 2.3 - 2.5). Further the importance of considering the broader range of EWE impacts including those related to the supply chain was elaborated (see Section 2.5.2). Whilst previous researches reported that SMEs have been affected detrimentally by EWEs during recent years, it is the common consensus of previous studies that SMEs have still to consider the risk of EWEs and to address the risk adequately. Previous research has also shown that construction SMEs are some of the most vulnerable to EWEs and are destructively affected by EWEs (see Section 2.6).

Due to the nature of their operations it can be assumed that construction SMEs are aware of the threat of EWEs to their core-business activities; their projects, and have adequate coping measures in place. However, evidence suggests that this is not the case as construction SMEs were found to be the SMEs most devastatingly affected by EWEs in the UK (see Sections 2.6.2 - 2.6.4). Lack of in-depth research and evidence to convince construction SMEs of the need to consider the risks of EWEs and develop their resilience adequately also seems to have contributed towards their lack of action regarding EWEs.

Addressing the need for enhancing the EWE resilience of construction SMEs and the need for in-depth research in this regard, research was undertaken to address the problem of “how to improve the resilience of construction SMEs to EWEs”. Consequently, several research questions are raised that lead towards addressing this primary research problem;

1. How do EWEs affect the activities of construction SMEs?
2. How do construction SMEs perceive the risk of EWEs and their impacts?
3. How do construction SMEs currently cope with the effects of EWEs, and why do/do not they implement coping measures?
4. What are the good practices that enhance the resilience of construction SMEs against EWEs?
5. Can a decision making framework be developed to help construction SMEs to assess the risk of EWEs on their businesses?

Having established the research problem for the study, the next stage is to develop a conceptual framework to depict how it is conceptualised in the research study. For that reason, the next section presents the conceptual framework developed for the study.

2.9 Conceptual framework

Following the review of existing literature a conceptual framework was developed for the research study. The conceptual framework sought to represent the theoretical basis for how it is proposed to address the research problem defined for the study.

2.9.1 Conceptual frameworks in PhD research

Miles and Huberman (1994) mention that “a conceptual framework explains, either graphically or in narrative form, the main things to be studied – the key factors, constructs or variables – and the presumed relationships among them”. According to them a conceptual framework can either be rudimentary or elaborative, theory-driven or commonsensical, descriptive or even casual. Yin (2003b) mentions that researchers are able to illustrate the main concepts pertaining to the study as well as to illustrate how the concepts are interrelated, and the circumstances within which the concepts and interrelationships are said to be true by conceptualising the phenomenon under study. Summarising several views on conceptual frameworks, Kulatunga (2008) identifies the main concepts, their interrelationships and the presence of a boundary within which the concepts and their interrelationships are applicable as the constituent parts of a conceptual framework.

According to Miles and Huberman (1994), developing a conceptual framework is an iterative process. A conceptual framework once developed will be revisited and amended as required during the course of a study, as the study progresses. However, having a conceptual framework in a research study is important as it provides a sense of direction and focus for the study. Focusing and bounding functions of conceptual frameworks are highlighted by Miles and Huberman (1994). Further, Easterby-Smith et al (2008) mention that the conceptual models are meant to guide and align the thinking of researchers into more productive channels but not to restrict their thinking. It is further identified that different researchers might come up with different conceptual representations for the same general topic, depending on their educational and cultural backgrounds and their

research experience. Therefore, it is important to have a framework which represents how the individual researcher conceptualises his/her research, in order for the study to be developed productively.

2.9.2 Conceptual framework of the research

Figure 3 shows the conceptual framework developed for this research. As mentioned in the introduction section (Section 1.4), the aim of this research is to investigate the resilience of construction SMEs to EWEs. Accordingly, a conceptual framework was developed to represent the theoretical concepts behind what resilience is envisaged in a construction SME context.

In this PhD research, resilience to EWEs is viewed as a combination of the vulnerability, coping mechanisms and coping capacity of a certain SME. It is thought that the level of vulnerability, presence or absence of coping mechanisms, and coping capacity of a certain SME will determine what level of resilience it can achieve against EWE impacts. It became evident following the discussions on resilience and related terminology that these issues are not mutually exclusive, but overlap and are interrelated.

The conceptual framework incorporates the views of organisational resilience as put forward by the likes of McManus et al (2007) and Linnenluecke and Griffiths (2010) and general resilience as put forward by Cutter et al (2008). Cutter et al (2008) viewed the impact of an EWE on a certain entity as a cumulative effect of several key issues in addition to the characteristics of the EWE itself. The level of impact and, thereby, the level of resilience required of the SME will depend on a number of complex and interrelated issues. Accordingly, in this research resilience is seen as a collective effect of

vulnerability, coping strategies and coping capacity (see Section 2.7 for definitions of these terms).

The conceptual framework specifically acknowledges the broader nature of EWE impacts that extend beyond the physical boundaries of an SME, throughout its supply chain. As discussed in the Section 2.5.2, SMEs may experience negative impacts of EWEs due to their supply chain partners being affected by EWEs and vice versa. This interconnected business environment is considered important if SMEs are to enhance their resilience to EWEs.

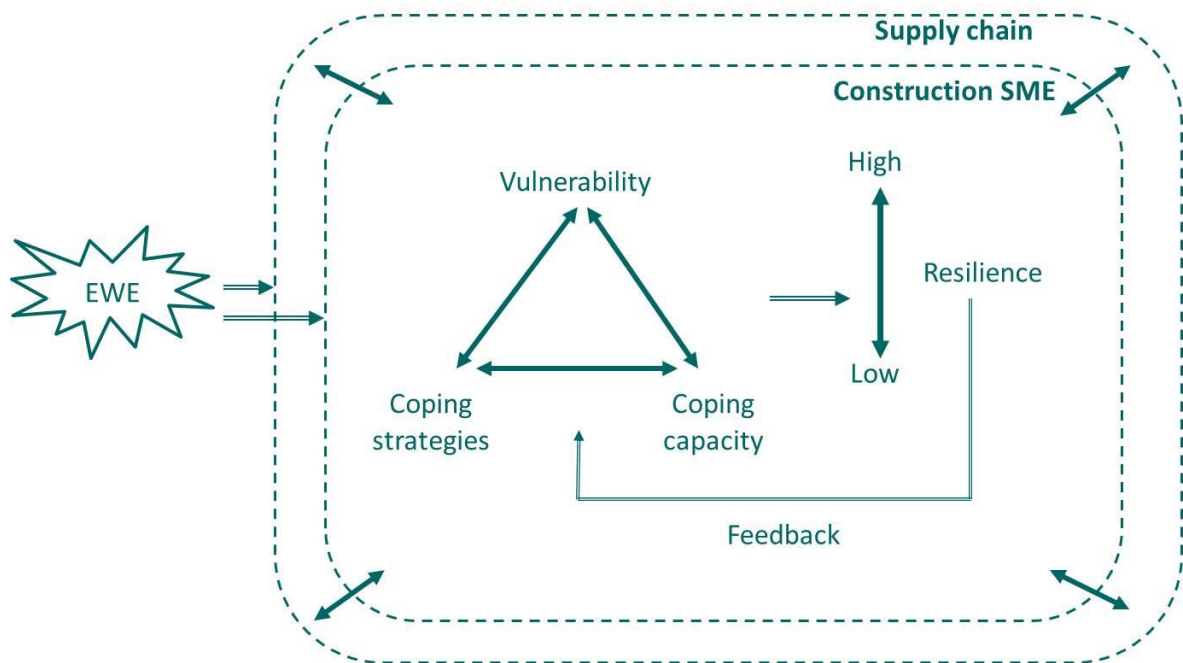


Figure 3 - Conceptual framework of the research

A somewhat similar framework for assessing and improving organisational resilience has been proposed by McManus et al (2007), in which the resilience is identified as “a function of an organisation’s situation awareness, management of key vulnerabilities, and adaptive capacity in a complex, dynamic and interconnected environment”. Their

framework for organisational resilience focuses on organisations in general and their resilience to disasters in general. However, since this research is primarily focusing on SMEs and their resilience to EWEs, a somewhat different framework is proposed, especially considering the characteristics of SMEs in comparison to larger businesses as well as the aim and objectives of the research. As mentioned above, the framework addresses the aim and the objectives of the PhD research. This framework will be revisited and further developed as the evidence emerges from the primary research. Further, the theoretical viewpoints behind the conceptual framework will form the basis for the decision making framework that will be developed to enable construction SMEs to assess the risk of EWEs on their business activities and thus provide a source of reference to which they can refer when making business decisions in regard to EWEs.

As mentioned above, the framework presents the theoretical concepts behind how resilience is envisaged in a construction SME context. Accordingly, the conceptual framework seeks to represent how resilience to EWEs can be achieved from a construction SME perspective as opposed to representing how decisions are made in relation to resilience. Whilst the framework is influenced by the findings of studies reporting on the behaviour of organisations with regard to EWEs; such as the studies by Berkhout et al (2004) and Lindell and Perry (2012), it has to be noted that the objective of the framework is different to that of models / frameworks representing the decision making process relating to EWEs.

2.10 Summary and link

This chapter reviewed the literature on SMEs, construction SMEs, EWEs and their impacts on SMEs, the concept of resilience and related terminology as well as resilience of

construction SMEs to EWEs. How EWEs can impact on SMEs was discussed, including potential business closure. Evidence suggested that EWEs seem to have a more elongate affect on construction SMEs than on SMEs in other industry sectors. However, construction SMEs was also identified as a sector that can derive positive impacts from being resilient to EWEs. Yet resilience to EWEs was not identified as a business issue that is given due consideration in business decision making within construction SMEs. This was partly attributed to lack of research in the area. On this premise, this study can be identified as a valuable addition to the construction management body of knowledge.

Following the establishment of the need for in-depth research on construction SME resilience to EWEs and the need for a novel approach to assessing their resilience, a conceptual framework was developed to represent what are seen as key factors influencing the extreme weather resilience of construction SMEs. Having established the “what” components about the study the next stage is to address the “how” component, by discussing the research methodology adopted in the study. Accordingly, the next chapter discusses the research methodological structure of the study.

3 CHAPTER 3 – RESEARCH METHODOLOGY

3.1 Introduction

Literature related to key knowledge domains pertaining to the study were reviewed in the previous chapter and a conceptual framework for the study was developed. This chapter seeks to discuss the research methodological design of the study in detail. The “research onion” model as suggested by Saunders et al (2009) is adapted therein, as the model offers clarity over different aspects that have to be considered in designing a research study. Accordingly, research philosophy, approach, strategy and techniques applicable to the study are detailed in this chapter.

3.2 Research methodological design

Remenyi et al (2003) described methodology as the “overall approach to a problem which could be put into practice in a research process, from the theoretical underpinning to the collection and analysis of data”. Summarising the above definition, Collis and Hussey (2009) identified methodology as the “overall approach to the entire process of the research study”. Research methodology, as per the above definitions, is focused around the problems to be investigated in a research study and hence is varied according to the problems to be investigated. This section describes the research methodology adopted to investigate the research questions which were developed to achieve the aim and objectives of this research.

Saunders et al (2009) presented the overall research methodology in the form of an “onion”, in which the thoughts with regard to the research problem lie in the centre and thus several layers have to be “peeled away” before coming to this central position. These

layers are the important aspects to be considered in determining the research methodology for a particular research study. The research onion suggested by Saunders et al (2009) is somewhat similar to the hierarchical model developed by Kagliouglu et al (2000). The “research onion” was adopted here as it offers clarity over the different aspects to be considered in determining the research methodology (See Figure 3). The following sections describe the layers of research philosophy, research approach, research strategy, research choice and research techniques of the “research onion” with regard to this research.

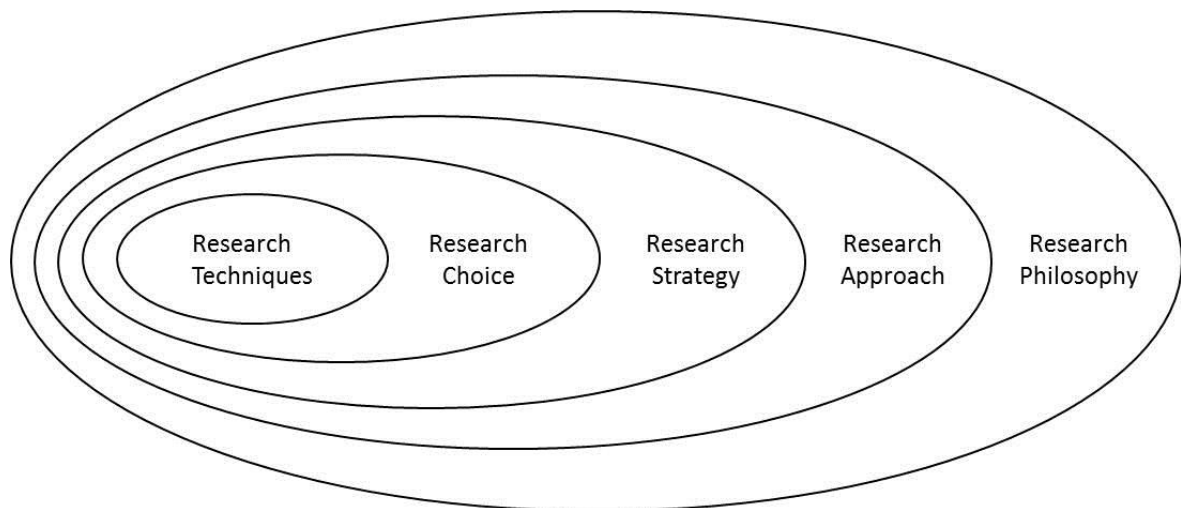


Figure 4 - Research Onion - Adapted from Saunders et al (2009: 108pp)

3.3 Research philosophy

Research philosophy, according to Saunders et al (2009), relates to the development of knowledge and the nature of that knowledge. Research philosophy contains important assumptions about the way in which a particular researcher views the world, and those assumptions will underpin the research strategy and the methods the researcher chooses as part of the strategy (Saunders et al., 2009). Thus, it is important to assess these

assumptions as they will determine the course of the research study. Further, Easterby-Smith et al (2008) mentioned that understanding the research philosophy enables the researcher to clarify the research design, recognise which research design is appropriate, and to be creative and innovative in selection or adoption of methods. Saunders et al (2009) identified epistemology, ontology and axiology as the three main ways of thinking about research philosophy.

Epistemology concerns what constitutes acceptable knowledge in a field of study. It is related to the relationship between the researcher and what is being researched. According to Saunders et al (2009) and Collis and Hussey (2009), the two ends of epistemology are positivism and interpretivism. Burns (2000) identified positivism from the viewpoint that scientific knowledge is the only valid form of knowledge and thus emphasis is placed on the role of discrete and distinct steps on the path to knowledge as the best way of discovering issues. The key ideas behind this philosophical stance are that it assumes that the social world exists externally and that its properties should be measured through objectively rather than subjectively (2008), and that the research will be undertaken, as much as possible, in a value-free way (Saunders et al, 2009). In contrast, interpretivism is an epistemology that advocates that it is necessary for the researcher to understand the differences between humans in their role as social actors and to emphasise those differences when conducting research among people rather than objects (Saunders et al, 2009). Adopting a somewhat different approach, Easterby-Smith et al (2008) identified the two extremes of the epistemology spectrum as that of positivism and social constructionism. According to them, social constructionism assumes that reality is determined by people rather than by objective and external factors. From

these definitions it seems that the terms interpretivism and social constructionism resemble each other quite closely. Saunders et al (2009) identified a view that lies in-between the two extremes of the epistemological spectrum as pragmatism, in which the research question determines the epistemological stance.

This research seeks to study how EWEs affect construction SMEs, how they respond to such weather extremes, and how they can improve their resilience to such weather extremes. Depending on the nature of these research questions it can be identified that they occupy a in between stance on the epistemological spectrum; that of pragmatism. As this research involves the study of organisational behaviour, especially that of SMEs which are by definition managed generally by owner managers in a more personal way than a large business organisation (Bolton, 1971; Holmes and Gibson, 2001; Analoui and Karami, 2003), it can be argued that the epistemological positioning is inclined more towards interpretivism than towards positivism.

Saunders et al (2009) identified ontology as a view concerned with the nature of reality which raises questions about the assumptions researchers make about the way the world operates and their commitment to particular views. Objectivism and subjectivism are the two extremes on the ontology spectrum. It has to be identified here whether the study is objective and external to the researcher, or socially constructed and only understood by examining the perceptions of the human actors (Collis and Hussey, 2009). This research deals with both subjective and objective issues and thus falls in between the two extremes on the ontology spectrum.

Axiology is a branch of philosophy that studies judgements of values (Saunders et al, 2009). It is concerned with whether the values of the researcher play a role in the study or not. In this research, since the researcher's values affect the research techniques used and the way the results of the study are interpreted, it can be identified that the research leans more towards a value laden stance. Figure 4 shows the philosophical stance of this research.

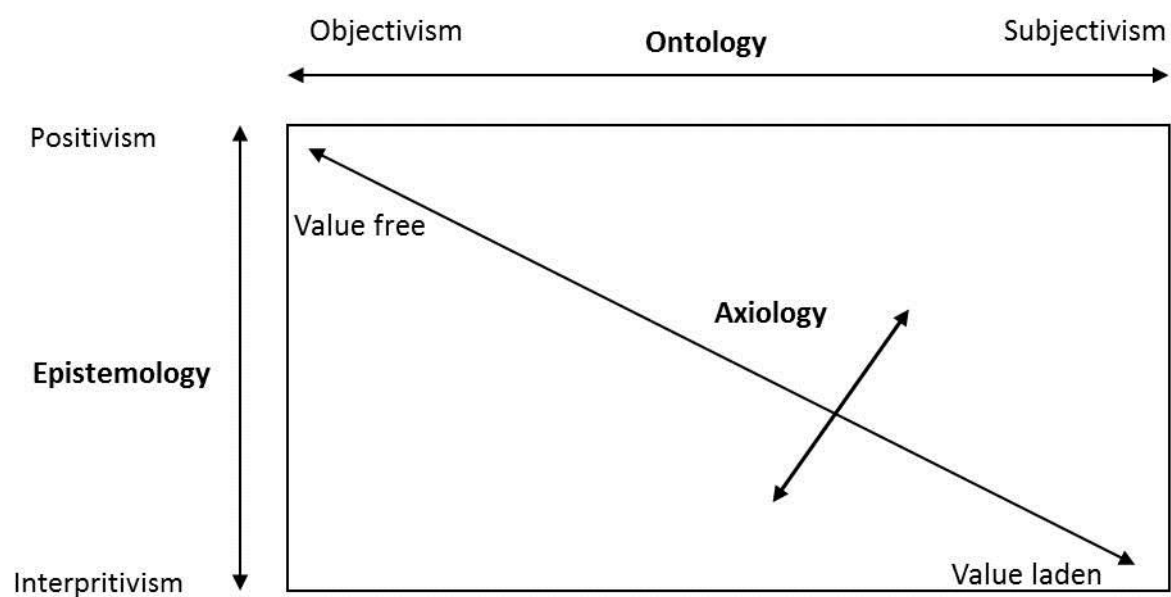


Figure 5 - Philosophical stance of the research - Adapted from Sexton (2007)

3.4 Research Approach

Saunders et al (2009) mention that the extent to which a researcher is clear about the theory at the beginning of the research raises important questions about the research design and which research approach will be employed. They identified two alternative approaches that can be adopted; deduction (testing theory) and induction (building theory). According to them a choice has to be made as to whether to use the deductive approach in which the researcher develops a theory and hypothesis and designs a

research strategy to test the hypothesis; or the inductive approach in which the researcher collects data and develops theory resulting from analysis of the data collected.

Collis and Hussey (2009) defined deductive research as “a study in which a conceptual and theoretical structure is developed and then tested by empirical observation; thus, particular instances are deduced from general inferences”. As per this definition, deduction can be identified as a process of starting from the general context and arriving at a specific context. This, as mentioned above, involves building theory and hypothesis, and rigorously testing the developed hypothesis to validate the developed theory. Inductive research, according to them, is “a study in which theory is developed from the observation of empirical reality; thus, general inferences are induced from particular instances”. Contrary to the deductive approach, in induction the general context is arrived at by studying a specific context. Although these two approaches differ from each other rather contrastingly, Saunders et al (2009) mentioned that it is possible to combine these two approaches in a research study and use a mixed or combined approach as well.

In this research, both the inductive and deductive reasoning is used. The deductive approach is used at the literature review stage and the questionnaire survey stage. The deductive approach is used at these stages to identify the specific issues to be studied in the research in depth via the inductive approach. This research seeks to develop a decision making framework for construction SMEs to improve their resilience against EWEs. It thus attempts to study the individual construction SMEs response to EWEs and then to arrive at conclusions applicable to the general population of construction SMEs. By looking at these aspects of the research it can be identified that it employs the inductive research approach. Curran and Blackburn (2001), also acknowledge that in

practice small business research more commonly follows some variant of the inductive approach than its counterpart.

Adopting a different classification, Creswell (2003) identified three research approaches; quantitative, qualitative and mixed methods. The same classification is also used by Saunders et al (2007), but to denote “research choice” not research approach. Creswell (2003) defined the quantitative approach as “one in which the researcher primarily uses post-positivist claims for developing knowledge, employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data”. This approach is quite similar to that of deduction as the quantitative approach involves reduction to specific variables and hypothesis, and testing of theories. The qualitative approach, according to Creswell (2003), is “one in which the researcher often makes knowledge claims based primarily on constructivist perspectives, or advocacy/participatory perspectives or both”. Under the qualitative approach the researcher, according to Creswell, collects open-ended, emerging data and develops themes from the data collected. This approach closely resembles the inductive approach discussed above. Whilst acknowledging such over simplification may create confusion, Easterby-Smith et al (2008) identify, in simple terms, an important distinction between the quantitative and qualitative approaches, being that the former involves data which relates more to numbers and the latter involves data mainly in the form of words. A mixed method approach is “one in which the researcher tends to base knowledge claims on pragmatic grounds”, and in which the researcher uses both the quantitative and qualitative data to better understand the research problems (Creswell, 2003). Here, the researcher selects an appropriate mix of both methods to arrive at a research approach

that best suits the research concerned. Bryman (2006) remarks that research that involves the integration of quantitative and qualitative data has been increasingly implemented in recent years.

Accordingly, this research sought to adopt a mix of both qualitative and quantitative approaches. The research involves interaction with SMEs to identify and explore in depth the individual behaviour of these SMEs in response to EWEs. The qualitative approach warrants a more in depth study of a particular phenomenon than the quantitative approach which tends to capture the broader width of a phenomenon rather than the depth. The research also seeks to utilise the quantitative approach in order to narrow down the research focus and to identify the specific issues to be studied in depth via the qualitative approach as the research develops. Further justification for adopting a mixed method research approach is provided in Section 3.6, in the research choice section.

3.5 Research strategy

Research strategy, according to Remenyi et al (2003), provides the overall direction of the research including the process by which the research is conducted. Saunders et al (2009) mention that the appropriate research strategy has to be selected based on the research questions and objectives, the extent of existing knowledge on the subject area to be researched, the amount of time and resources available, and the philosophical underpinnings of the researcher. Adopting a quite different approach, Yin (2003b) recommended that a particular research strategy has to be selected based on three conditions; the type of research question, the extent of control an investigator has over actual behavioural events, and the degree of focus on contemporary or historical events. There are various different research strategies with distinctive characteristics from which

a researcher may select, based on the above criteria. Both Yin (2003b) and Saunders et al (2007) acknowledged that although various research strategies exist there are large overlaps between them and hence the important consideration would be to select the most advantageous strategy for a particular research study. Some of the common research strategies used in business and management are experiment, survey, case study, action research, grounded theory, ethnography, archival research, cross sectional studies, longitudinal studies and participative enquiry (Saunders et al., 2007; Easterby-Smith et al., 2008; Collis and Hussey, 2009). From these various strategies, this research sought to adopt the case study research strategy as the appropriate strategy for the research. The following sections briefly describe the case study strategy and rationale for selecting case study research as opposed to other strategies.

3.5.1 Case study

Yin (2003b) defined case study research as an “empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident” (pp13). This part of Yin’s definition covers the scope of case study research whereas a second part covers the range of characteristics. This part of the definition acknowledges that the phenomenon and context are not always clearly distinguishable in real-life contexts. Technical characteristics included in Yin’s (2003b) definition included; case study deals with technically distinctive situations, relies on multiple sources of evidence, and benefits from prior development of theoretical prepositions to guide data collection and analysis. Yin (2003a) identified case study as the preferred research strategy when the phenomenon and the context are not readily distinguishable. Highlighting that Yin’s definition does not

capture one of the distinctive characteristics that case study research has over other research methods; which is the use of a single case or a small number of cases, Dul and Hak (2008) defined case study as “a study in which (a) one case (single case study) or a small number of cases (comparative case study) in their real life context are selected and (b) scores obtained from these case are analysed in a qualitative manner” (2008, p4).

Although case study research is more often associated with contemporary phenomenon, as highlighted in Yin’s definition, Eisenhardt and Graebner (2007) point out that case studies can also be historical. The definition put forward by Collis and Hussey (2009), also identified some of the discernible characteristics of case study method. They defined case study as “a methodology that is used to explore a single phenomenon in a natural setting using a variety of methods to obtain in-depth knowledge”. Therefore, it can be seen that case study research is capable of accommodating different research techniques and is normally used when in-depth knowledge is required with regard to a particular phenomenon. Case study research, moreover, can accommodate both qualitative and quantitative data (Yin, 2003b), allowing the researcher to get a rich mix of data for the study.

3.5.2 Rationale for selecting case study strategy

The rationale for selecting case study as the overarching research strategy for the study is discussed in the following sub-sections.

3.5.2.1 Satisfying the criteria for selecting case study strategy

Yin (2003b) recommended satisfying three conditions to decide upon a research strategy. These were; 1. Type of research questions posed, 2. The extent of control the researcher

has over actual behavioural events, and 3. The degree of focus on contemporary issues (pp5). Accordingly, case study is preferred when the research questions take the form of “how” and “why”. The doctoral research reported here was developed to answer the research questions of;

1. How do EWEs affect the activities of construction SMEs?
2. How do construction SMEs perceive the risk of EWEs, their impacts and vulnerability to EWE impacts?
3. How do construction SMEs currently cope with the effects of EWEs on them?
4. What are the factors that determine the resilience of construction SMEs to EWEs and how to improve their resilience to EWEs?
5. Can a decision making framework be developed to help construction SMEs to assess the risk of EWEs on their businesses?

Looking at the research questions it can be noted that they predominantly consist of how and why type of research questions, favouring a case study research.

The second condition identified by Yin (2003b), is the degree of control the researcher has over actual behavioural events. In this research, the researcher did not have control over the behaviour of construction SMEs or the EWEs that impact them. The researcher was outside the “case”, construction SMEs, and was an observer. Further, there was no possibility of manipulating the behaviour of SMEs (independent variable) in order to investigate the impact on a dependent variable. Further the issues being investigated were contemporary and about how the construction SMEs are affected, respond and cope with EWEs currently; satisfying the third condition for selecting case study research.

3.5.2.2 Appropriateness for investigating the research in hand

The context of the study is construction SMEs. Perren and Ram (2004) noted that case study research is gaining acceptance within the small business research community. Moreover, Chetty (1996) concluded that utilising case study research in an SME context leads to the observation of new insights that would not have emerged through a strategy like a large survey. This was of particular importance to the research at hand as the existing literature was limited with regard to construction SMEs' response to EWEs. From a construction industry perspective, the likes of Sexton and Barrett (2003a), Sexton et al (2006), Ribeiro and Fernandes (2010), and Rezgui and Miles (2010) have successfully used the case study method to study construction SMEs, suggesting the applicability of the strategy in studies involving construction SMEs.

Proverbs and Gameson (2008) mentioned case study as highly relevant to an industry like construction which comprises different types of businesses and organisations. It was further noted that application of case study research in the construction management domain remains low and that there is significant scope for further application within this domain. Dainty (2008) identified quantitative methods as the dominant research paradigm within construction management research, confirming the claim of Proverbs and Gameson (2008) that the application of case study research within this domain is limited.

The above discussions illustrates that the case study strategy has been and can be used successfully to conduct research into SMEs in construction. In fact, it can be argued that the case study strategy, where in-depth knowledge can be obtained, suits the study of a heterogeneous sector like SMEs; where it is often difficult to make strong generalisations

across the sector due to the significant differences that exist between different construction SMEs.

3.5.2.3 Ability to accommodate different research techniques

The objectives and the research questions investigated in the research favoured a combination of different research techniques for data collection and analysis. For instance, the objective of identifying the coping strategies employed by SMEs favoured a questionnaire survey approach in order to identify a range of coping strategies, whereas the objective of assessing the current coping capacity of construction SMEs favoured a method that warrants in-depth analysis, hence semi-structured interviews were preferred. Adopting a case study strategy allowed the use of multiple sources of data collection and analysis allowing the researcher to address the research objectives and answer the research questions satisfactorily. The ability to accommodate different research techniques, both qualitative and quantitative, is a salient feature of case study research (Yin, 2003b; Gerring, 2007). Accordingly, it was fitting to use semi-structured interviews, a questionnaire survey and document review as the data collection techniques, whereas content analysis, cognitive mapping, and quantitative analysis were used for data analysis.

It was thought that opting for a mixed method research design would also contribute towards methodological pluralism in construction management research, in which quantitative research is dominant, as identified by Dainty (2008). He called for greater use of qualitative approaches and adoption of a diversity of approaches, shifting away from the traditional positivist viewpoint in order to better understand the complex network of

relationships present within the industry. Fellows (2010) concluded that such methods are gaining recognition within the construction management body of knowledge.

3.5.2.4 Compatibility with the philosophical viewpoint

Based on the researcher's underpinning philosophical views, the research was positioned within the philosophical viewpoint of a pragmatist. According to Saunders et al (2009), pragmatism is based on the argument that "the most important determinant of the epistemology, ontology, and axiology you adopt is the research question" (p109). Whilst the research was positioned and approached from a pragmatic viewpoint, the nature of the research questions meant that the research was inclined towards interpretivism, subjectivism and value-laden research on the philosophical spectrums of epistemology, ontology and axiology. Although case studies can be conducted by adopting a positivist approach, for instance see Rezgui and Miles (2010), it is often associated with interpretivism/realism and pragmatism, for instance see Sexton and Barrett (2003a). Further, Sexton (2007) plotted different research strategies on the continuum of epistemology and ontology spectrums. Accordingly, case study research was placed between the two extremes (realism/positivism and idealism/interpretivism), within the territory of idealism/interpretivism, suggesting that it is common for case studies to be adopted in such a philosophical positioning. Hence, it was established that case study research was compatible with the philosophical positioning of the research, supporting the case for adopting case study as the preferred research strategy.

3.5.2.5 Suitability of case study research, over other research strategies

A research strategy such as experiment was considered less applicable to this study as the researcher did not have control over the phenomenon being studied. This was because

experimental studies attempt to manipulate independent variables to observe the behaviour of dependent variables (Collis and Hussey, 2009), which would not be achievable in this research. The survey strategy is usually associated with the deductive approach (Saunders et al., 2009), and positivist philosophical positioning (Collis and Hussey, 2009). As discussed previously, this research inclined towards interpretivism and undertook a more inductive approach, thus, a survey strategy was deemed inapplicable to this research. Ethnography requires the researcher to be immersed in a setting and become part of the group under study in order to understand the phenomenon being studied (Easterby-Smith et al., 2008). As the researcher was outside the context in this research, construction SMEs, ethnography did not seem to be an appropriate strategy for this research.

Grounded theory seeks to develop a well-integrated set of concepts that provide a thorough theoretical explanation of the phenomena under study (Corbin and Strauss, 1990). In grounded theory, theory is derived from data, systematically gathered and analysed through the research process in an iterative process (Bryman, 2008). Grounded theory can perhaps be identified as the next best alternative for this research, due to the nature of research questions being asked. However, this research sought to explore phenomena in a real-life context and examine how the issues with regard to the general SME population apply to construction SMEs. So, it was not purely attempting to generate theory out of data, but also sought to apply existing theory to construction SMEs. Hence, grounded theory was deemed less suitable when compared to the case study strategy.

3.5.3 Type of case study

Based on the purpose of the research, the research can be divided primarily in to three categories; exploratory, descriptive and explanatory (Saunders et al., 2009). This division is also applicable to case study research (Yin, 2003a, 2003b). Exploratory case study, according to Yin (2003a), aims to define the questions and hypothesis of a subsequent study or to determine the feasibility of the desired research procedures. Thus, it can be identified as the preliminary investigative stage of a more rigorous study to follow. A descriptive case study presents a comprehensive description of a phenomenon within its context, whereas an explanatory case study presents data associated with cause-effect relationships (Yin, 2003a). The objective of descriptive case study is, thus, to describe current practice (Scapens, 1990). The emphasis of explanatory research is to explain a causal relationship between variables by studying a particular phenomenon (Saunders et al., 2009).

In addition to these three types, Scapens (1990) identifies two more types of case study; illustrative and experimental. According to Scapens (1990), illustrative case studies attempt to illustrate new and possibly innovative practices developed by particular companies, and experimental case studies attempt to examine the difficulties of implementing new proposals and their benefits. However, it has to be noted that Scapens (1990) has mainly derived these two types from a management accounting perspective.

The case study phase of the research was developed as a descriptive study, following on from the exploratory questionnaire survey stage. The case study phase sought to describe the current practice of construction SMEs in relation to EWEs and obtain an in-depth account of the phenomenon under investigation.

3.5.4 Multiple or single case

Case study research can be based on single or multiple case studies (Yin, 2003a). Single case research typically exploits opportunities to explore a significant phenomenon under rare or extreme circumstances (Eisenhardt and Graebner, 2007). According to Yin (2003b), single case study design is appropriate when the case represents a critical case, an extreme case or a unique case, representative or typical case, revelatory case, or a longitudinal case. Multiple case studies involve more than a single case study. The evidence from multiple case studies is more compelling and the results are more robust (Remenyi et al., 2003). Yin (2003b) advised that multiple case designs are preferable to single case studies when the resources are available due to the expanded generalisability and the possibility of replication.

SMEs are a very heterogeneous group of businesses (Hallberg, 1999; Lukacks, 2005). The wide variety that exists within the SME community has made it difficult to make strong generalisations about the SME sector. The differences between owner-managed small firms with 10 or 20 employees and medium-sized limited companies with over 200 employees may even be greater than differences between the latter and large multidivisional organisations (Jones, 2003). Research into a heterogeneous sector like SMEs favoured a multiple case design in order to obtain a better understanding of the phenomenon being studied. Moreover, this research did not fall under the criteria identified by Yin (2003b) for selecting a single case design. Therefore a multiple case study design was proposed for this research.

3.5.5 Holistic or embedded

According to Yin (2003b), if the case study examines only the global nature of an organisation or of a programme, it is called a holistic design and if the case study examines more than one unit of analysis with a single case it is called an embedded design. According to Yin (2003b), holistic design is preferable when no logical subunits can be identified within the case or when the relevant theory underlying the case study is holistic in nature. This research sought to undertake an embedded design due to the unit of analysis adopted as described below.

3.5.6 Unit of analysis

In this research, a “case” was taken to be a construction SME and two units of analysis were defined within a case (See Figure 5). The unit of analysis for this research was primarily taken as the response of construction SMEs to EWEs. A subunit was defined as the response of construction projects to EWEs. Therefore, the research sought to adapt a multiple embedded case study design.

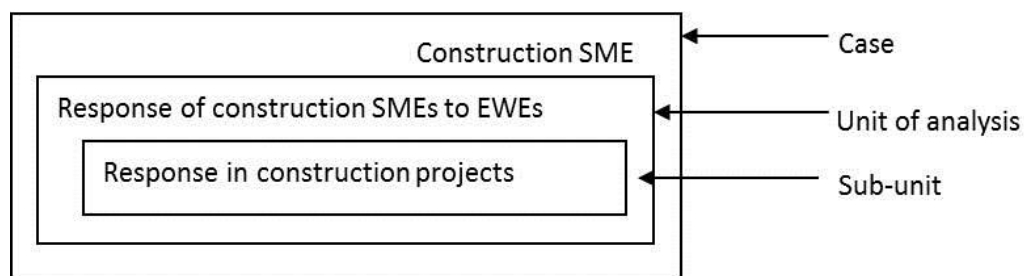


Figure 6 - Case and the unit of analysis

3.6 Research choice

According to Saunders et al (2009), research choice refers to the way in which the quantitative and qualitative techniques and procedures are selected to be combined in a

research study. As discussed in Section 3.4, quantitative and qualitative approaches can be combined to suit the particular research in hand and to answer the research questions raised.

Saunders et al (2009) identify the mono method and multiple method as the two main branches of research choice. In the mono method a single data collection technique and a corresponding data analysis techniques is used, whereas in a multiple method more than one data collection and analysis techniques are used. Multiple methods are further subdivided as multi method and mixed method, as shown in Figure 7 (Saunders et al, 2009). In the multi method more than one data collection technique and corresponding analysis techniques are used within either qualitative or quantitative approaches. Therefore, multi method choice can be further sub-divided into multi method qualitative studies and multi method quantitative studies. Contrastingly in mixed method, both qualitative and quantitative data collection and analysis techniques are used in combination. Sub variants of the mixed method are mixed method research and mixed model research. In mixed method research, although both qualitative and quantitative data collection and analysis techniques are used, qualitative data are analysed qualitatively and quantitative data are analysed quantitatively. In mixed model research however, these may be combined.

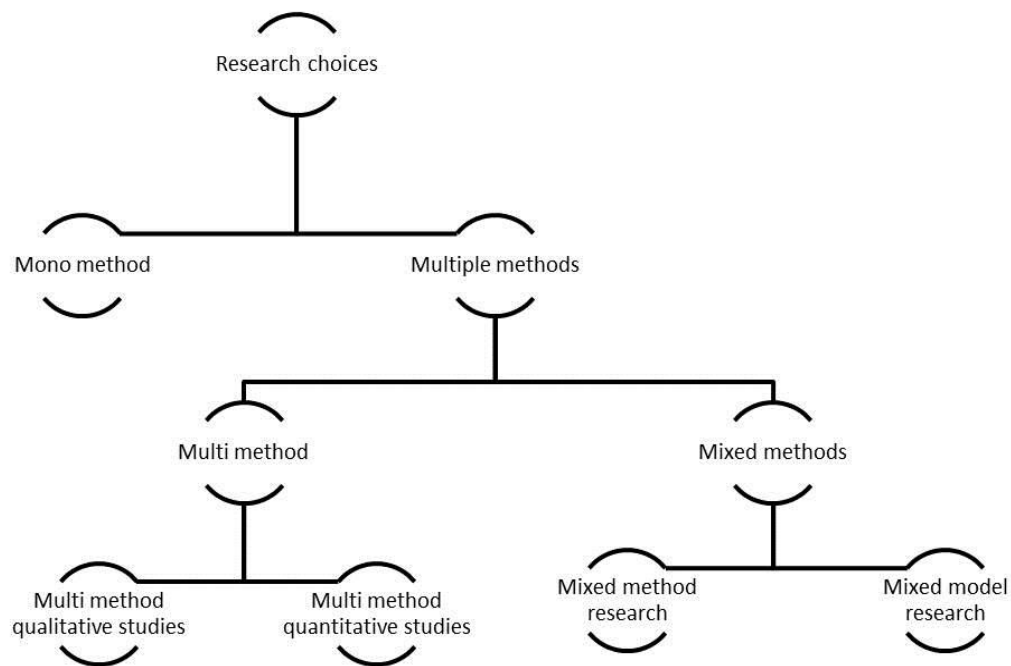


Figure 7 - Research Choices (Saunders et al, 2009)

From within these choices, a mixed method research choice is adopted in this study. As Robson (2011) notes, mixed method research design is compatible with the pragmatic philosophical stance, as adopted in the study. Further, Curran and Blackburn (2001) identified that mixed method approaches are common in small business research and are capable of deriving benefits from triangulation and characteristics inherent to both quantitative and qualitative approaches. Dainty (2008) and Fellows (Fellows, 2010) call for methodological pluralism in construction management research and assert that rigorously adopting a diversity of approaches will increase the understanding of the complex network of relationships pertinent to the industry. A similar viewpoint has previously been put forward by Love et al (2002). Use of a mixed method approach in this research was considered appropriate to further enhance the knowledge of the research issues being investigated, but also in answering the call for a multi-paradigm approach to

construction management research as opposed to the traditional positivist approach. Endorsing the findings of Adolphus (2013), the mixed method research approach adopted for this research study has not only acted in a complementary way to each other, as the results from the case studies have shed further light on the questionnaire survey findings, but has also initiated new knowledge and further research questions.

3.7 Research techniques

As a mixed method research choice was selected for the study, both qualitative and quantitative data collection and analysis techniques were used. The research techniques used for data collection and analysis are briefly outlined in this section. Figure 8 highlights the overall research process of this doctoral study and the different data collection techniques used. Accordingly the study primarily consisted of the data collection techniques of questionnaire survey and case studies comprising of semi-structured interviews and extended structured interviews. Figure 8 also shows how the doctoral study links with the Community Resilience to Extreme Weather - CREW research project (see Appendix-B for a brief description about the CREW research project), of which the doctoral study is a part.

Accordingly, the exploratory questionnaire survey was conducted in conjunction with the doctoral study and the CREW project and contained questions specifically addressing the research objectives of each study as well as common questions such as business demographics. Case studies of construction SMEs were undertaken specifically for the purpose of the PhD to address the aim and objectives of the study and the data collection instruments, including the decision making framework, were developed exclusively for

the PhD study. Techniques used for data collection and analysis in the research are discussed in following sub sections.

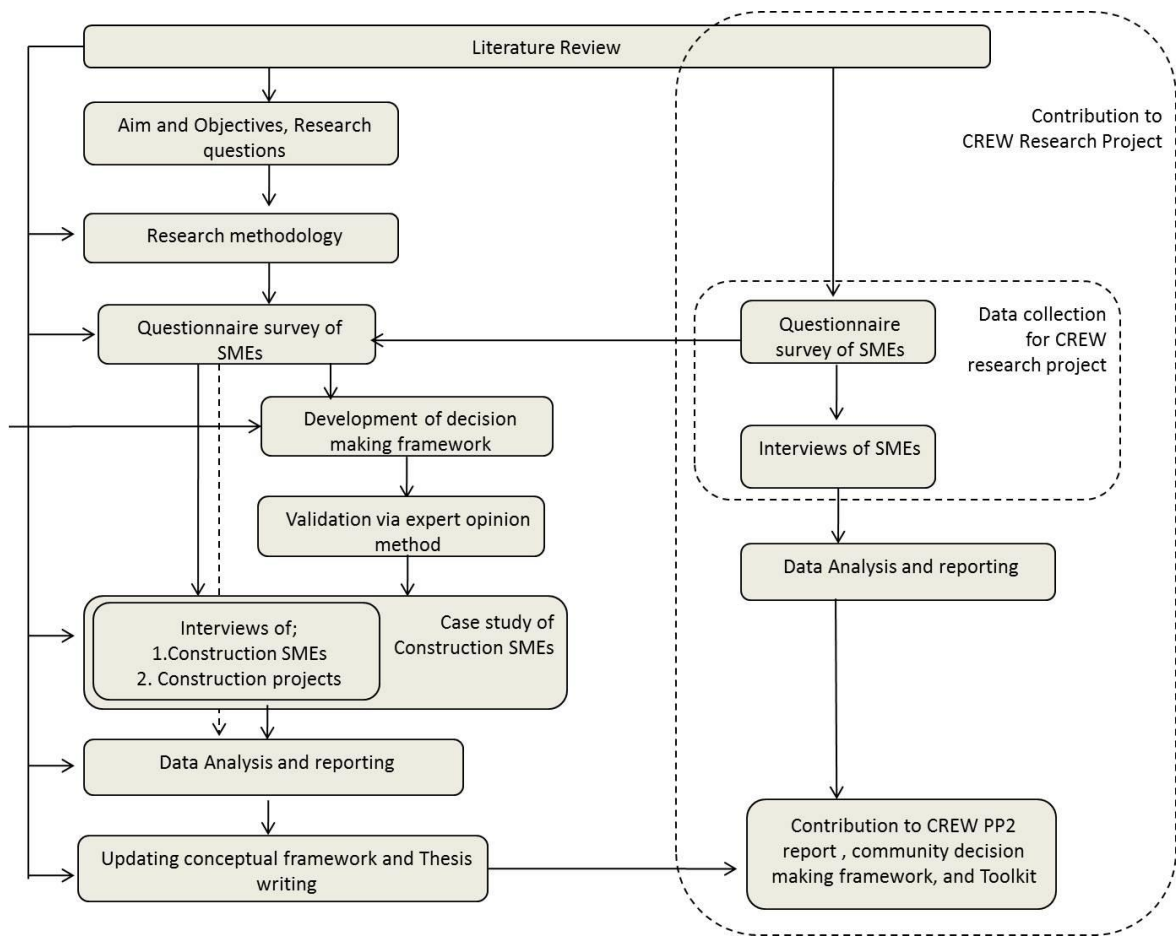


Figure 8 - Overall research process

3.7.1 Data collection

According to Yin (2003b), evidence for a case study research can be collected via six main sources; documents, archival records, interviews, direct observation, participant-observation, and physical artefacts. Yin (2003b) also mentions that a case study need not be limited to a single source of evidence but that it can also encompass various quantitative data collection techniques. Accordingly, this research sought to employ the questionnaire survey method as a forerunner to the case study research to collect data

for quantitative analysis and also to verify the focus and content of case study research, and this was followed by interviews with SME employees to collect data for qualitative analysis; which Haigh (2008) identified as one of the recurrently utilised data collection technique in research related to built environment. This will also improve the construct validity of the case study research. This will also improve the construct validity of the case study research.

3.7.1.1 Questionnaire survey

The questionnaire survey technique was used in this study to identify the initial scope of the problem. This phase informed the mainstream case study research stage to gain a better understanding of the common issues affecting SMEs with regard to EWEs; especially to address one of the objectives of the research; to investigate existing coping strategies of SMEs against EWEs. Further, the results of the questionnaire survey informed the interview stage (focus, direction and content of semi structured interviews) and the important aspects identified were addressed in detail. The sample studied also involved SMEs from other industry sectors in order to facilitate comparison between construction SMEs and SMEs from other sectors. This research design allowed the researcher to determine how the results of other studies conducted elsewhere in the UK and other parts of the world are applicable to construction SMEs. Further, the philosophical positioning of the study as well as the selected research strategy, case study method, were compatible with such a research design. As the findings by Adolphus (2013) affirm, the questionnaire survey in the study has complemented the main case study research to follow, and has also raised new research questions that were answered at the case study research stage.

Questionnaire survey template design

The questionnaire survey was conducted as an online survey among the SMEs located in the Greater London area with the help of the Federation of Small Businesses (FSB). The survey template was piloted firstly via the Greater London FSB leaders (5 SME owners/managers) and then via several borough council representatives of Greater London. The questionnaire contained mainly structured questions with space to include any specific issues/comments from the respondents. The survey was limited to SMEs located within a target area as it was thought that this would provide more context to the findings and aid meaningful analysis.

Survey target area

According to the London Climate Change Partnership – LCCP (2002), London is particularly vulnerable to EWE hazards such as flooding as a significant proportion of London lies within the floodplain of the River Thames and its tributaries. Currently, 15% of London lies on floodplains of its rivers (Greater London Authority, 2010). London is susceptible to flooding by five sources; tidal, fluvial, surface water, sewer, and groundwater flooding possibly by a combination of several sources simultaneously (Greater London Authority, 2010). Climate change is expected to have an impact on these sources. For example, more frequent intense winter rainfalls are expected to increase the likelihood of flooding by rivers and flash floods in the future and the risk of tidal flooding is also expected to increase due to climate change (LCCP, 2002).

London is considered to be particularly sensitive to extreme temperatures especially due to the heat island effect (LCCP, 2002). Further, the study area is among the worst-affected areas of the heavy snowfall of 2009 (BBC News, 2009). The London community risk

register (London Fire Brigade, 2010) identifies fluvial flooding as a very high risk hazard requiring immediate attention (see Figure 9). It also identifies tidal flooding and other weather extremes such as storms and gales, low temperatures, heavy snow, heat wave and surface water flooding as significant risks affecting London. Thus, Greater London was selected as an appropriate area for this research study.

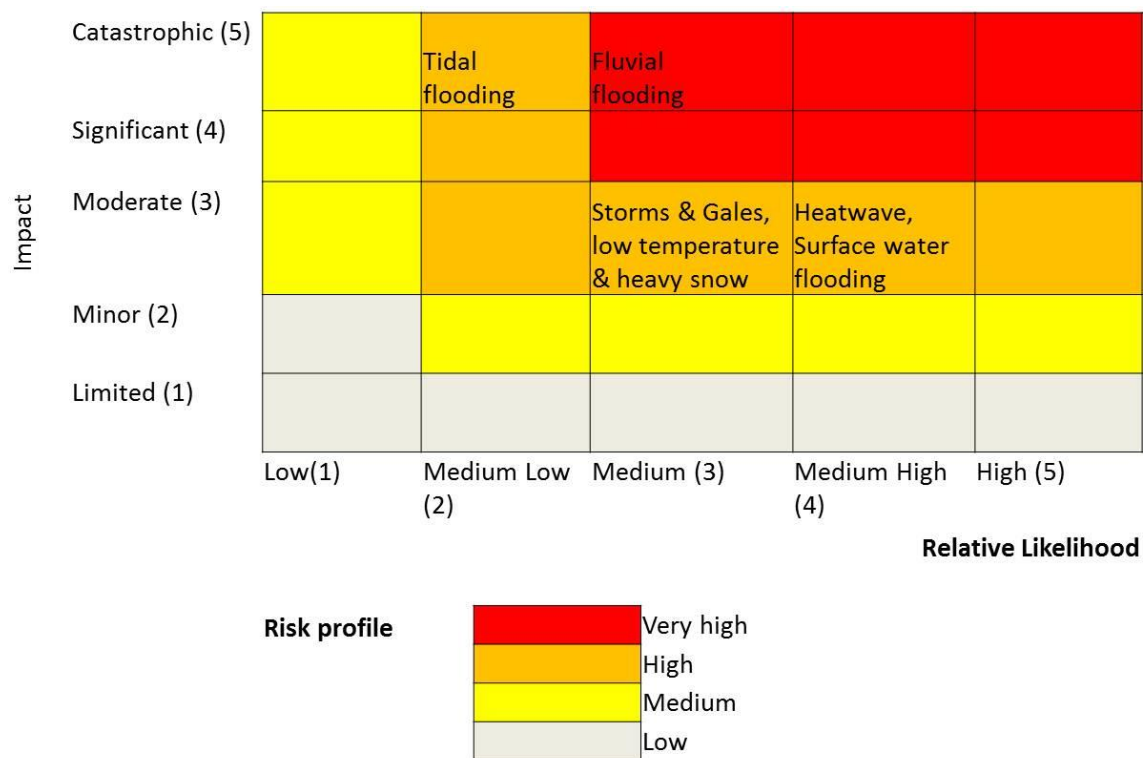


Figure 9 - Risk matrix of extreme weather hazards for London. Adapted from London Fire Brigade (2010)

Sampling and survey distribution

A self-selective, non-probability sampling technique was used to arrive at the sample for the questionnaire survey. As noted by Saunders et al (2009), a self-selective sampling technique is preferred when the research conducted is exploratory. This phase of the research, the questionnaire survey, was conducted as an exploratory survey as a

forerunner to the case study interviews. Therefore, the sampling technique adopted is suited to the research requirements.

Accordingly, emails with a link to the online questionnaire were sent out to the membership of the FSB, via FSB. The target respondents were the senior management of the SMEs responsible for strategic/higher level operational decision making within their businesses and involved proprietors, managing directors, directors, partners, and Chief Executive Officers (CEOs). The questionnaire survey received 140 completed responses from SMEs operating in Greater London. This involved 20 construction sector SMEs. The sample respondents to the questionnaire survey are largely representative of the SME population in the UK, both in terms of organisation size (as a measure of number of people employed) and the industry sector. The top management of the SMEs were mainly involved in the survey such as managing directors, owners, sole proprietors, partners, and directors, who are responsible for high level decision making in their businesses. The questionnaire responses were then analysed and compared with the current literature. Along with literature review, the findings of the questionnaire survey informed the design of the data collection instruments of case study interviews.

3.7.1.2 Semi-structured interviews

The semi-structured interview technique was used as the main case study data collection technique for the study, along with that of document analysis where applicable. Bryman (2008) and Cassell (2009) identified interviews as probably the most widely utilised method in qualitative research and Yin (2003b) identified this approach as one of the most important sources in case study research. It is a method for collecting data in which selected participants are questioned in order to find out what they do, think or feel (Collis

and Hussey, 2009). Semi-structured interviews allowed collection of specific information from different SMEs whilst maintaining a consistent line of inquiry. Interviews were conducted with both the senior management and the site management of selected projects in the organisations chosen for case study interviews.

Selection of case studies (SMEs interviewed)

The purposive sampling technique was adopted for selecting construction SMEs as case studies. According to Saunders et al (2009), purposive sampling enables a researcher to use his/her own judgement in selecting cases in a way that best enables the researcher to answer the research questions and accomplish the research objectives. Yin (2011) commented that purposive sampling was likely to be used in qualitative research where samples are selected in a deliberate manner. Yin (2011) highlighted that the reasoning behind the use of purposive sampling was to select the cases that could provide the most relevant and rich data.

Accordingly, two in-depth case studies were developed to explore the context within which construction SME's interpret and respond to EWEs. The first case study was a building contractor (CSA) and the second a civil engineering contractor (CSB). Both SMEs are medium-sized businesses employing between 50 and 249 employees and are well established construction organisations that have been in business for several decades. These two cases were selected to obtain the perspectives of both building and civil engineering construction SMEs. Further details about the case study SMEs are provided in the findings and analysis chapter.

In each case, a construction project which had been affected by a recent EWE was studied to obtain an understanding of on-site issues related to EWEs. The projects studied were (CSA) a residential development (CSAP) and (CSB) a land remediation and earthworks project (CSBP).

Case study informants (Interviewees)

In each case, respondents from the head office as well as the site management of the selected projects were interviewed (see Table 11). In the case of CSA, the managing director (CSA1) and the project manager of the selected project (CSAP1) were interviewed. In the case of B, three senior managers (CSB1, CSB2, and CSB3) as well as the project manager of the selected project (CSBP1) were interviewed. In CSA, the organisational structure and the decision making responsibility within the SME meant that it is sufficient to obtain information only from CSA1, as CSA1 was directly responsible for both strategic and operational decision making. However, CSB being a much larger organisation with a more complex decision making structure; interviews were conducted with three senior management level interviewees. These personnel had responsibility for direct operational decision making within the SME. Further details about the interviewees are provided in the data analysis chapter.

Table 11 - Case study informants

Case	Project	Interviewees
CSA		CSA1
	CSAP	CSAP1
CSB		CSB1 CSB2 CSB3
	CSBP	CSBP1

3.7.1.3 Extended structured interviews

Following the semi structured interviews with the case study SMEs, extended structured interviews were conducted. These were targeted at the same case study SMEs but the main objective was to gather the information required to complete the risk assessment template developed and piloted for the study (See appendix - F). This step also helped verification of information gathered via semi-structured interviews and further analysis; thus contributing towards reliability and validity of the research findings as well as analysis of rich qualitative data.

Participants for the extended interviews were the business level interviewees involved at the semi-structured interview stage. In the event of case study SME CSB, the extended interview was conducted as a group interview, involving CSB1, CSB2 and CSB3. This was because the risk assessment template developed through this research study is aimed at enhancing decision making in relation to EWEs within construction SMEs. In case study SME CSB, the size of the business (medium sized business with more than 200 employees) and the decision making procedure within the organisation meant that a collective approach is likely. Further, the risk assessment template developed is best completed by construction SMEs as a group exercise involving strategic and operational decision makers within the business as in the case of BACLIAT toolkit developed by the UKCIP (Metcalf et al., 2009).

3.7.2 Data analysis

As per the research choice adopted for this study, quantitative data collected via the questionnaire survey are analysed quantitatively, whereas qualitative data gathered via

semi-structured interviews and document reviews are analysed qualitatively. These techniques are explained below.

3.7.2.1 Quantitative data analysis

Answers to some of the questions in the survey were gathered via a five-point Likert scale. Depending on the analysis requirements and the type of scale used, weightings were allocated to the Likert scale options during the analysis of some of the questions. Weighted scores were then ranked using the Relative Importance Index (RII) method. RII is a method used to evaluate the comparative importance of a single item to others (Yang and Wei, 2010), and has been used successfully to rank factors according to their relative importance in construction management research (Kometa et al., 1994; Akintoye et al., 1998; Yang and Wei, 2010).

Accordingly, RII is calculated as;

$$RII = \frac{\sum w}{A \times N}$$

Where, “w” is the weighting given to each impact by the respondents, “A” is the highest weighting with “N” being the number of respondents. Instances where the RII method is used for analysis have been mentioned where such data is discussed and analysed.

As the questionnaire survey was exploratory, the objective was to collect data from a much larger sample than that of a case study to inform the case study stage rather than to perform rigorous quantitative analysis. Therefore, these data are analysed using simple statistical techniques such as average, mean and percentages.

3.7.2.2 Qualitative data analysis

Data collected from the interviews are analysed using qualitative data analysis methods such as content analysis and cognitive mapping. Content analysis is a technique in which the researcher interrogates data for constructs and ideas that have been decided in advance (Easterby-Smith et al, 2009). This technique is used especially when in depth analysis of issues pertaining to research questions and key issues identified during the questionnaire survey stage is required. Krippendorff (2004) identified that content analysis can take the form of word count or thematic, conceptual analysis. Word count of a particular issue may not provide an accurate reflection of the importance of the issue being discussed, and may result in some of the important issues discussed being unexploited by the researcher. In conceptual content analysis the text is scrutinised to check the existence of a concept, considering terms related to the concept both implicitly and explicitly (Krippendorff, 2004). In this study, conceptual content analysis is used, in order to make sure that even the issues mentioned few times are picked up in the analysis if such issues are deemed to have a relatively higher significance or provide new knowledge. Therefore, the content analysis adopted in the research is qualitative, and the qualitative content analysis forms a major part of the qualitative data analysis.

Cognitive mapping is also used to identify and analyse new concepts emerging from interview data and to identify relationships between different issues. Cognitive mapping is a technique used to structure, analyse and make sense of accounts of problems (Ackermann et al., 2004), which are often derived from interviews and which provide valuable analysis of the subjective views of the interviewees (Eden, 1992). On a similar note, Soetanto et al (2011) recognised that cognitive mapping was a technique that

facilitated information structuring, elaboration, sequencing and interaction amongst participants. The technique therefore is considered beneficial in analysing case studies. Cognitive mapping will be used in the study to structure, sequence and visually represent the perspectives of case study SMEs to the different issues being studied. Morgan et al (2001) concluded that mental maps, such as those developed through cognitive mapping, can help individuals and organisations to develop clear and understandable messages about risks and to effectively communicate the risks. The advantage of cognitive mapping will particularly benefit the study by facilitating visual representation of issues related to the risk of EWEs and aid effective communication of the study findings among construction SMEs / industry practitioners.

According to Eden (2004), cognitive maps derived for organisational studies (as in this study) are likely to be small, whereas maps generated for structuring issues in operational research are likely to be large. It was noted that group maps created by combining a number of individual maps can be very large. Eden (2004) discussed seven types of analysis that can be performed on cognitive maps, especially to analyse large cognitive maps. As noted by Eden (2004), it is often better to analyse the emerging characteristics from a small map through words and extensive analysis is not required to identify the emerging characteristics. On a similar note, Kulatunga (2008) and Fernando (2011) have used cognitive mapping to represent and analyse organisational issues in the built environment, without conducting extensive analysis such as domain, central or cluster analysis. As the cognitive maps developed in this study fall in to the category of small as defined by Eden (2004), this approach is adopted in the study.

The qualitative data analysis process was facilitated by the use of the computer software package NVivo which allows analysis of data using qualitative techniques. Accordingly, cognitive maps were generated by the use of the software. Figure 10 highlights the data collection and analysis techniques used in this doctoral research.

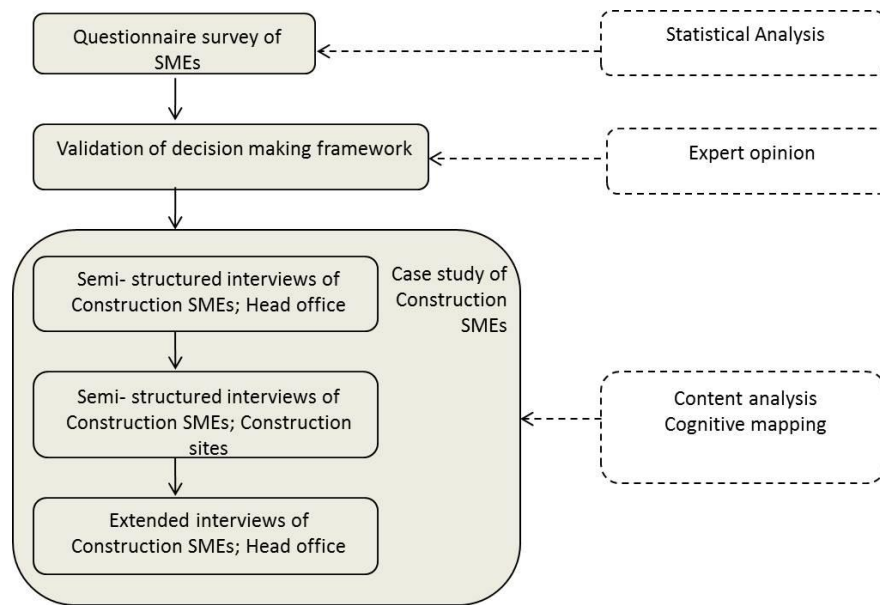


Figure 10 - Data collection and analysis techniques used in the research

According to Eden and Ackerman (1998), cognitive maps are developed from interviews by breaking down the account of a problem to its constituent elements which are then reconnected to represent the account of the problem in a graphical format. Eden and Ackerman (1998) suggested a set of guidelines that have to be followed in developing cognitive maps from interviews. These guidelines were followed to develop cognitive maps from interviews with the construction SMEs in the study. The stepwise procedure adopted to develop cognitive maps is identified below.

- Interview transcripts uploaded to NVivo were coded by scrutinising for meaningful content categories related to a particular concept. Accordingly, transcripts were

scrutinised for main concepts related to research questions and the objectives of the study.

- When a new concept was identified, a code was assigned. This process was followed until no new concepts, and therefore, no new codes were identified. These “free nodes” were then transferred into hierarchical “tree nodes”.
- “Tree nodes” facilitated the structuring of concepts in a logical manner according to the relationship between the concepts in a hierarchical structure. The research questions of the study were broken down into sub themes and these sub themes were used as the tree nodes for the study using a tree structure. The free nodes that were developed were then transferred to these tree nodes.
- Cognitive maps were created by using the modelling function in NVivo. Accordingly, nodes pertaining to a particular issue were projected onto models.
- Relationships between different nodes were completed based on the views expressed by the respondents as well as how the issues were viewed by the researcher.

3.8 Development of the decision making framework

As identified in Section 1.4, one of the objectives of the study was to develop and validate a decision making framework that can be used by construction SMEs to improve their resilience to EWEs. However, this aspect of developing an artefact is often omitted from the research methodology in social science, business, and construction management research. But it is intended here to briefly discuss this aspect within the research methodology section as observable in constructive research (Koskela, 2008; Oyegoke, 2011). Kasanen (1993: 245) identified constructive research as “*managerial problem*

solving through the construction of models, diagrams, plans, organisations, etc". Whilst it is not intended to place the study within a constructive research context (as the sole objective is not just to develop a decision making framework), it is intended to follow the process as recommended in constructive research in developing the framework, as it provides a step-wise guide which is otherwise unfounded in the research domains mentioned above. Kasanen (1993) recommends a six-phase process to develop solutions as follows;

- Find a practically relevant problem with research potential.
- Obtain a general and comprehensive understanding of the topic.
- Innovate / construct a solution / idea.
- Demonstrate that the solution works.
- Show the theoretical connections and the research contribution of the solution concept.
- Examine the scope of applicability of the solution

In this study, the research problem was arrived at by reviewing literature which was further explored thereafter to obtain a comprehensive understanding of the topic. Following the review of literature, the decision making framework was developed based on the conceptual framework of the study. The decision making framework developed takes the form of a template for Extreme Weather resilience assessment based on the concepts behind the conceptual framework; i.e. resilience as a collective effect of managing vulnerability, implementing coping strategies, and enhancing coping capacity. The framework was then validated using the expert opinion approach.

Expert opinion was obtained on the developed framework from academics as well as industry practitioners. Accordingly, the framework was reviewed by two professors with expertise in construction management and construction SMEs as well as two industry practitioners; a micro-sized construction SME owner and a managing director of a micro sized construction SME. Several modifications were made to the decision making framework following this stage; for example by reducing the number of options for identifying resilience indicators from five to three (See Appendix - K for how the key comments were addressed). The extended interviews were then conducted with the case study SMEs to complete the risk assessment. As elaborated in the Section 0, the extended interviews conducted with the case study SMEs contributed towards completing the risk assessment as well as providing rich data for qualitative analysis.

3.9 Validity and reliability

As case study research is often subjected to criticism it is important that validity and reliability of a case study research is established by following the tests of construct validity, internal validity, external validity and reliability; as identified by Yin (2003b).

3.9.1 Validity

According to Bryman (2008), validity is concerned with the integrity of the conclusions that are generated from the research. Robson identifies validity as *“whether the findings are ‘really’ about what they appear to be about”* (Robson, 2011: 77). Collis and Hussey (2009: 64) identify validity as the *“extent to which the research findings accurately reflect the phenomena under study”*. Whilst expressed in different terms, the underlying basis of these definitions points out the need for establishing whether the beginning (e.g. research questions), middle (e.g. data collection and analysis), and end points (e.g.

conclusion) of a research study are coherent. Table 12 lists how this research sought to achieve validity and reliability.

Yin (2003b) discusses three variants of validity; construct validity, internal validity and external validity. Accordingly, construct validity relates to establishing the correct operational measures for a particular study. According to Yin (2003b) the use of multiple sources of evidence; literature review, questionnaire survey, case study, and document review in this research, is one way of ensuring construct validity. Further, interview transcripts were reviewed by the interviewees ensuring that their views were correctly recorded, as proposed by Yin (2003b). Moreover, as per Yin's (2003b) definition of construct validity, it can be argued that establishing an appropriate research methodology from start to finish of a research study is also a way of instituting the construct validity of a research, which has been achieved via this chapter.

Table 12 - Case study tactics for establishing validity and reliability (adapted from Yin, 2003b)

Test	Case study tactic used in the research
Construct validity	Use of multiple sources of evidence Review of draft case study reports by key informants Establishing chain of evidence (i.e. audit trail; for e.g. case study protocol, interview transcripts, coding structures) Establishing an appropriate research methodology
External validity	Review of key literature Use of replication logic
Reliability	Use of case study protocol Documenting each operational stage of the research Expert opinion method

Internal validity relates to establishing a causal relationship where certain conditions lead to other conditions (Yin, 2003b). According to Yin (2003b), this test applies to explanatory /casual studies only. The case study stage of this research was primarily descriptive, whereas the precursory questionnaire survey was exploratory. Therefore, the test of internal validity does not apply to this research, as per the explanation put forward by Yin (2003b).

External validity refers to whether the findings of a particular study are generalisable beyond the immediate case study (Yin, 2003b). In this research, external research is achieved by a review of key literature and relating the findings to literature as well as comparing the findings at different stages of data collection; i.e. cross-case analysis and cross analysis of questionnaire survey and case study data.

As noted by Robson (2011), triangulation is a way of countering all of the threats to validity in flexible research designs such as involving case study and mixed method research. Triangulation involves the use of multiple sources of evidence throughout the study, in addition to the data collection stage as prescribed by Yin (2003b). Haigh (2004) summarised triangulation as the combination of qualitative and quantitative techniques to effectively exploit the strengths of each technique and counteract weaknesses. Denzin (2006) differentiated between four types of triangulation; data triangulation, methodological triangulation, theory triangulation, and observer triangulation.

Accordingly, opting for different data collection and analysis techniques (data triangulation), adopting a mixed method research choice (methodological triangulation), and a multi-disciplinary literature review extending well beyond the construction

management body of knowledge (theory triangulation) can be cited as some of the triangulation techniques adopted for this study. Observer triangulation, however, is difficult to achieve in a doctoral study where a single observer/researcher is primarily involved. Love et al (2002) articulated triangulation as an appropriate approach for extending the scope of construction management research, which is expected to be achieved in this study by adopting the aforementioned triangulation techniques.

3.9.2 Reliability

According to Yin (2003b), reliability involves determining that the operations of a study can be repeated to obtain the same results. Yin (2003b) recommends use of a case study protocol and case study database to establish reliability. These approaches were adopted within the study to enhance reliability of the study.

Whilst Yin's (2003b) definition of reliability is very much applicable to research undertaken from a positivist point of view, it may not be readily applicable to research undertaken from an interpretivist or pragmatic point of view. This is due to the fact that researcher's perceptions and world views have an impact on the research process. Hence, it may be difficult to reproduce the same results (Remenyi et al., 2003) in such research. Therefore, Remenyi (2003) and Easterby-Smith et al (2008) advocate demonstrating the transparency of the study through good practice guidelines. Robson (2011) recommends keeping a record of activity throughout the study. In this research, these are achieved by documenting each operational stage involved in the study within a methodology chapter and within the data analysis chapters to follow.

3.10 Summary and link

Establishing an appropriate research methodology is vital in addressing a research problem and achieving the research objectives, as well as establishing trustworthiness in a research. Within this chapter, philosophical positioning, research approach, strategy, choice and techniques are established whilst elucidating the reasoning behind the research methodological selections arrived at. Having reviewed key literature related to the study in Chapter 2, and establishing the research methodology in this chapter, the next stage involves reviewing and analysing primary data. Accordingly, the findings of the exploratory questionnaire survey are discussed and analysed in the next chapter.

4 CHAPTER 4 – FINDINGS AND ANALYSIS OF EXPLORATORY QUESTIONNAIRE SURVEY

4.1 Introduction

The literature on key issues pertinent to this study was discussed and reviewed in Chapter 2. This was followed by establishing the research methodological framework of the study in Chapter 3. Having established why and how the research is conducted, this chapter seeks to present, discuss and analyse the outcomes of the study, observed through the mixed method research adopted. First, the findings of the exploratory questionnaire survey are discussed. As discussed under Sections 3.7.1.1 and 3.7.2.1, an exploratory questionnaire survey was conducted involving construction SMEs, and SMEs from other industry sectors, in order to inform the case study research to follow. The findings of the survey are discussed and analysed in the succeeding sub sections. In addition to construction SMEs, a sample of other SMEs was also included in the study. Comparison is made to other SMEs where relevant in order to assess how construction SMEs differ or not from SMEs in general.

4.2 Demographics of the survey sample

The questionnaire survey involved 21 construction SMEs and 119 SMEs from other industry sectors. Construction SMEs amounted to 15% of the total sample (See Figure 11), as opposed to representing 17% of SMEs within the survey catchment area (BIS, 2011). Hence, it can be noted that construction SMEs are represented within the sample comparative to their representation within the population.

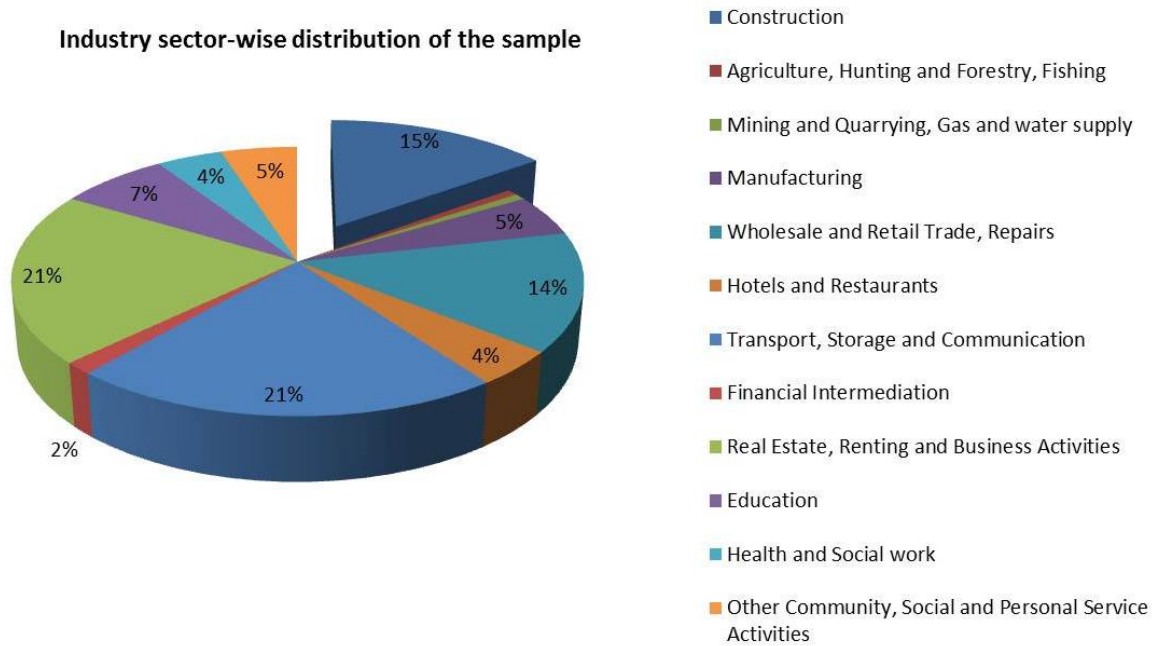


Figure 11 - Percentage of construction SMEs within the total sample

Out of the construction SME sample, 71% were micro businesses, whereas 24% were small and 5% were medium sized (See Figure 12). Representation of small and medium sized businesses within the construction SME sample is larger than within the population, where 98.5% are micro, 1.5% Small, 0.1% are medium sized businesses. This is due to the fact that a vast majority of SMEs in the construction sector are sole-proprietorships and micro businesses as discussed in the Section 2.6.1. However, a larger representation of small and medium sized businesses (29%) is desirable for the purpose of the study, as this will allow demonstrate the perspectives of structured SMEs with an employee base, where organisational dynamics are more likely to be present than would be in sole-proprietorships.

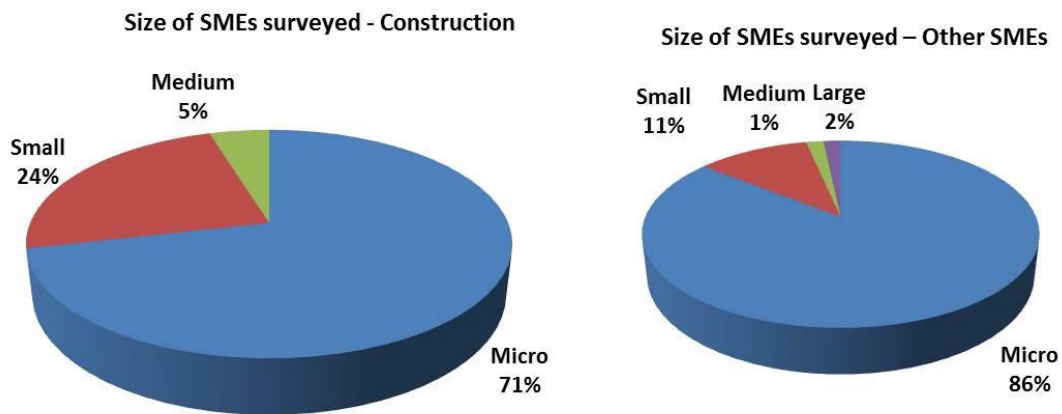


Figure 12 - Size-wise distribution of the sample

4.3 Experience of EWEs

Out of the construction SMEs surveyed, 71% have said that they were affected by an EWE between 2006 – 2009 (the survey was conducted in May-June 2009). For construction SMEs, heavy snowfall (62%) and heavy rainfall (33%) have been the most experienced EWEs (See Figure 13). Minor differences of opinions among construction and other SMEs regarding whether they were affected by an EWE seems to suggest that these two events have affected construction SMEs than others, but lesser in the case of other EWEs.

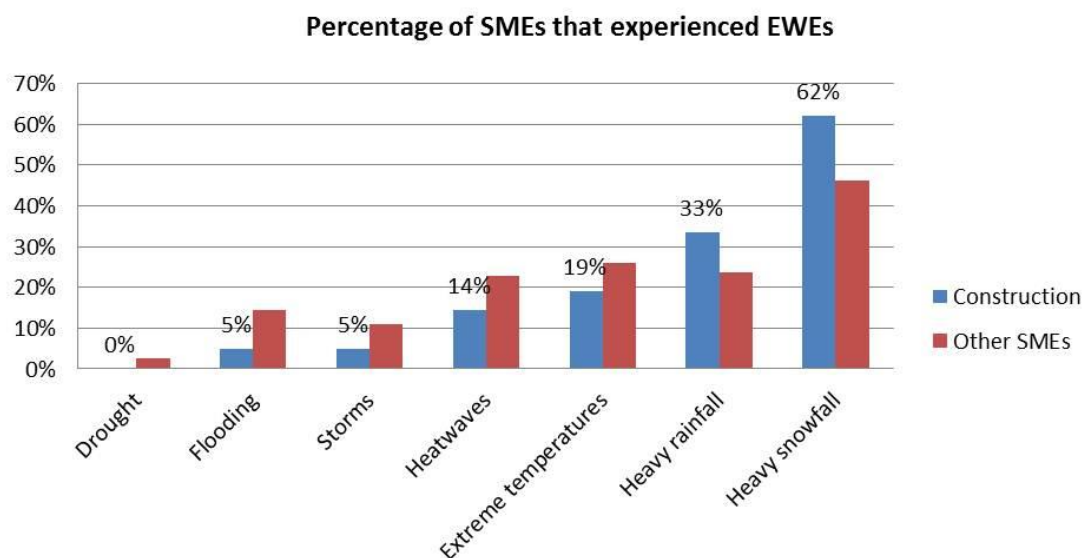


Figure 13 – Percentages of SMEs affected by an EWE

These findings suggest that the heavy snowfall that affected the UK (and London in particular, as discussed in Section 3.7.1.1) in February 2009 (BBC News, 2009) had a major impact on the SMEs in the region. A smaller percentage of SMEs reporting that they were affected by an EWE, especially in the case of flooding, is understandable given that the sample was not only aimed at EWE affected SMEs. For example, Wedawatta et al (2012) reported that 75% of the sample they studied were directly flooded SMEs, and that a further 17% had been affected indirectly in the Cockermouth flood event in 2009. However, the objective of their study was to investigate impacts, responses, and perceptions of SMEs faced with a devastating flood experience. In this study, focus is limited not only to flooding, but to EWEs in general. Therefore, the target area selected for the study was an area with a relatively high risk profile for a range of EWEs. Further, the study sought to investigate the perceptions of SMEs either with or without previous EWE experience. Therefore, the sample returned is considered appropriate for further analysis.

4.4 Impacts of EWEs on SMEs surveyed

As part of the questionnaire survey, SMEs were questioned on what impacts they experienced on their businesses in relation to the EWEs that affected them. Absence of employees, loss of production, disruption to access (to premises), and loss of productivity were the major impacts reported by the construction SMEs (See Figure 14). Although the options were provided, none of the SMEs surveyed indicated any positive effects of EWEs. This is noteworthy, given that previous studies have reported such positive effects and EWEs also have the potential of presenting SMEs with business opportunities (See 1.5.1.2).

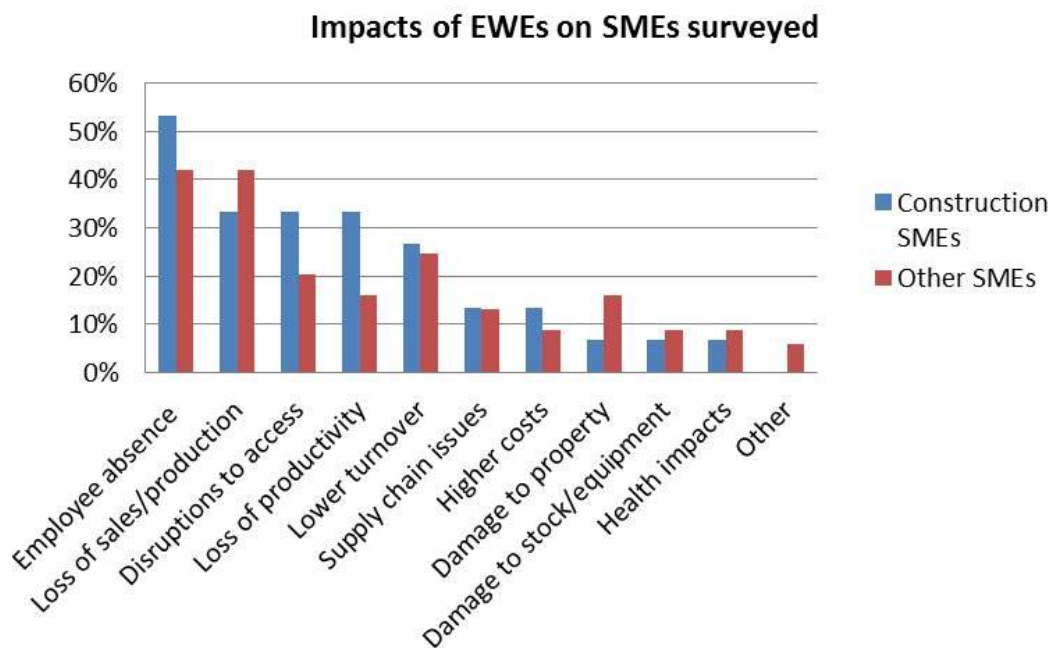


Figure 14 – Impacts of EWEs on SMEs included in the survey

In the cases of employee absence and loss of productivity construction SMEs have shown a higher tendency for being affected than other SMEs. This could be due to the fact that construction SMEs were expressing their impact in relation to construction projects where the EWEs can have a significant impact. For instance, where flexible or home working could be an option for other SMEs, this is unlikely to be helpful in the case of site operations of construction SME. Therefore, construction SMEs seem to suffer more than other SMEs due to adverse effects of EWEs on their workforce.

As mentioned above, in Section 4.2.2, the event that affected the vast majority of SMEs was the heavy snowfall in February 2009. The Likert scale options for the severity of impacts experienced revealed that the majority of SMEs considered that it had a minor impact on their businesses. As the survey was conducted between May and July of 2009, it could be argued that the impacts reported by respondents are more likely to be

associated with their last EWE experience rather than an objective assessment of effects of any previous EWEs. This would reinforce the view expressed by Desai and Jones (2010), where the facilities managers' attitudes to EWEs and climate change was investigated. Therein, it was identified that personal experience of an event was a factor in informing a manager's response to the risks posed by such an event. Similarly, Berkhout et al (2004) found that SMEs found it difficult to interpret climate stimuli unless there was an appropriate frame of reference.

One of the inherent difficulties of conducting a study of this sort is that the SMEs that suffered the most devastatingly affects due to an EWE might not be included in the sample when the survey is conducted afterwards. This is due to the probability that some of such SMEs might have already ceased to exist following the event. As noted by McWilliams (2009) , the heavy snowfall of February 2009 was estimated to have lead to more than 2000 additional business closures in the UK. Thus, there is the possibility that some of the worst hit SMEs might have already closed down and were not included in the sample. Therefore, it is possible that the impacts of EWEs may have been felt by more SMEs when the whole population is considered, than that is reported by the sample selected.

4.4.1 Impacts on SMEs due to supply chain disruptions caused by EWEs

As it was identified that supply chain disruptions in relation to EWEs can have a significant impact on SMEs, especially on construction SMEs (see Section 2.5.2), therefore, SMEs were asked whether they experienced any disruptions due to their supply chain being affected by EWEs. Therein, 38% of construction SMEs and 39% of other SMEs mentioned that they experienced disruptions due to their supply chain being affected by EWEs. As

discussed in Section 2.6.2, construction SMEs may suffer negative impacts indirectly, due to their supply chain being affected by EWEs, even though the SME was not physically affected by the EWE. The findings of the survey confirm this issue. Damages to/inaccessibility to road network, longer transport times, and delay in receiving supplies were the main supply chain disruptions reported by SMEs (See Figure 15). Construction SMEs seem to have suffered more by these three issues than the SMEs in other industry sectors. 23% of construction SMEs said that they were affected by the failure of businesses in their supply chain due to EWEs. This suggests that a considerable number of businesses in the supply chain of the construction industry have ceased to operate after being affected by EWEs.

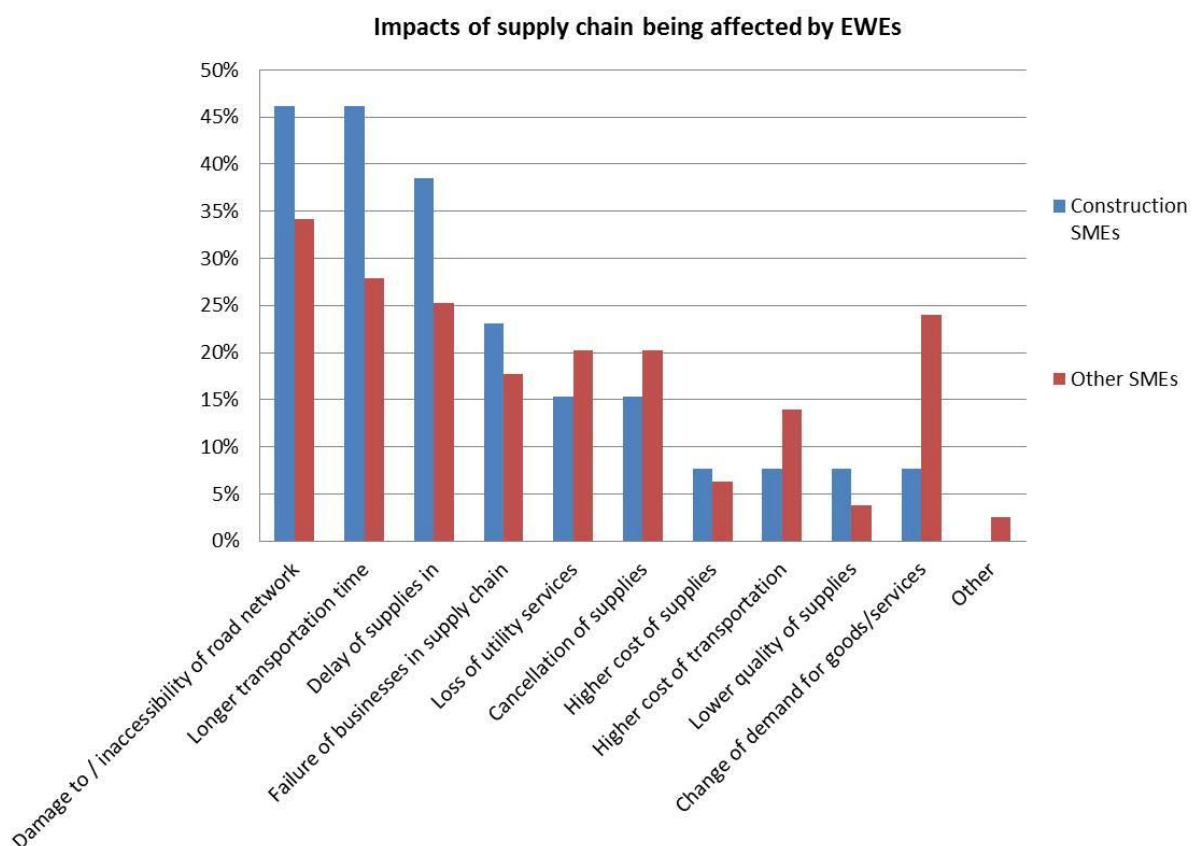


Figure 15 – Impacts on SMEs due to supply chain affected by EWEs

Indirect impacts experienced by SMEs, due to their supply chain being affected by EWEs, suggests the far reaching nature of EWE impacts and the importance for SMEs to consider both the direct and indirect effects of EWEs which may extend beyond the boundaries of their organisation. In the event of EWEs, supply chain related disruptions can sometimes produce the most damage to SMEs. For example, Wedawatta et al (2013) reported supply chain related disruptions as some of the major impacts experienced by SMEs following the Cumbrian floods. Similar findings were also reported by the Cumbria Intelligence Observatory (2010). Therefore, it is imperative that SME business planning considers the effects of EWEs on their supply chains, how those will be reflected in their business operations, and develop their coping strategies and coping capacity accordingly. Construction SMEs with supply chains that extend across regional, national and continental boundaries will have to assess such issues in detail due to the widespread nature and frequent occurrences of EWEs and natural disasters.

4.4.2 Impacts on the supply chain due to SMEs affected by EWEs

In order to investigate the other side of the story, EWE affected SMEs were questioned on whether their being affected by EWEs had any impact on their supply chain. The answers to this question revealed that this was the situation in most of the cases (See Figure 16). Delay in delivering products/services, longer transportation times, and having to cancel orders placed with suppliers were the three main such effects identified by construction as well as other SMEs. Delay in delivering products, i.e. project delays, is understandable in the case of construction SMEs, where project duration might have been extended for a period of time due to EWEs. All the construction SMEs who said they had to cancel products, presumably postponing construction work for a period of time or cancelling the

work completely, were micro businesses employing fewer than 10 people. Not being able to conduct work for a period of time can be particularly damaging for smaller businesses in construction, due to operating with a limited cash flow. This could be one of the reasons for many construction SME business failures following EWEs.

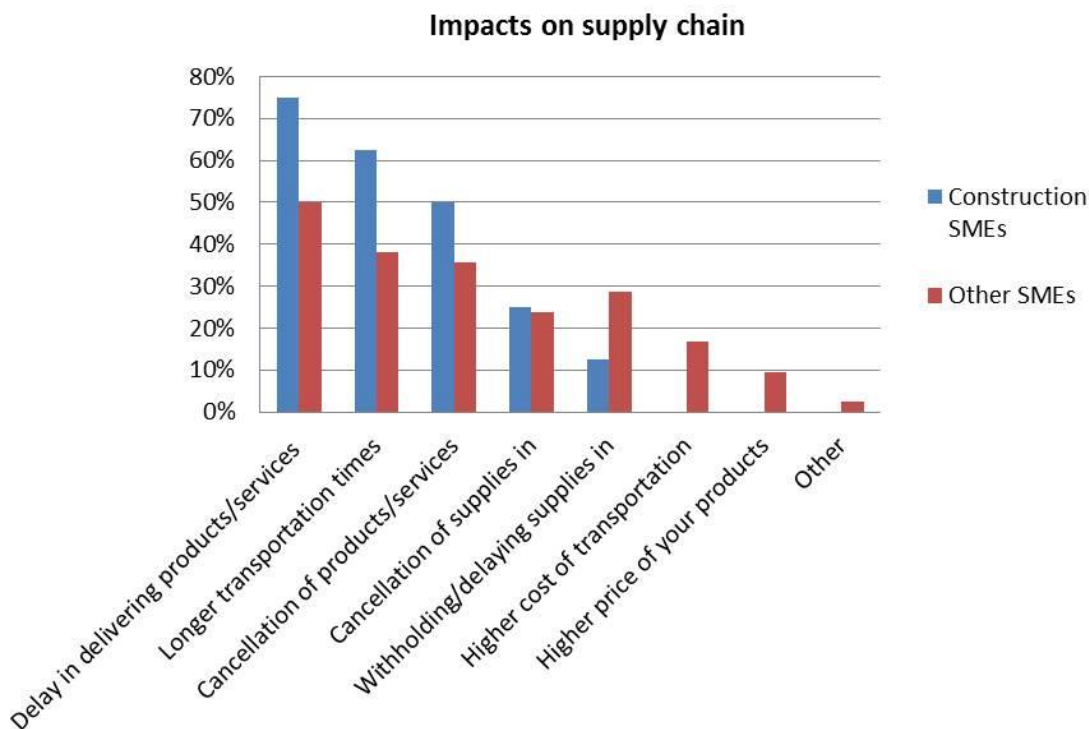


Figure 16 – How supply chain was affected due to EWE impact on SMEs

As the survey findings relating to supply chain disruptions both to, as well as because of construction SMEs, the indirect impacts of EWEs could also be substantial and could potentially have grave consequences for construction SMEs. Therefore, it is essential that any EWE risk assessment takes into account wider supply chain issues in addition to obvious direct impacts. An important aspect associated with a construction SME considering supply chain disruptions due to EWEs within their business planning is that this then has the potential of spreading through the supply chain to other businesses; for example sub-contractors, etc. If this planning can be done in consultation with supply

chain partners much of the disruptions would be avoidable, as well as contributing towards realising an efficient supply chain in construction.

4.5 Existing coping strategies

SME responses to their existing coping strategies revealed that a very significant majority of construction SMEs have not considered the risk of EWEs in their business planning (See Figure 17). 83% of construction SMEs with previous EWE impact experience said that up to now they have not implemented any coping strategies, whereas this figure was 38% in the case of other SMEs. Having a data backup system and developing a business continuity plan were the only coping strategies reported, albeit at a very low level. This is consistent with the findings of Berkhout et al (2004), who identified that SMEs found it difficult to assess the advantages and disadvantages of alternative adaptation strategies unless they had experienced severe disruption. Whilst the extent of coping strategies implemented by other SMEs was also low, this was not as low as in the case of construction SMEs. This further emphasises the importance of conducting this research study and validates the discussions in Sections 2.6.3 and 2.6.4.

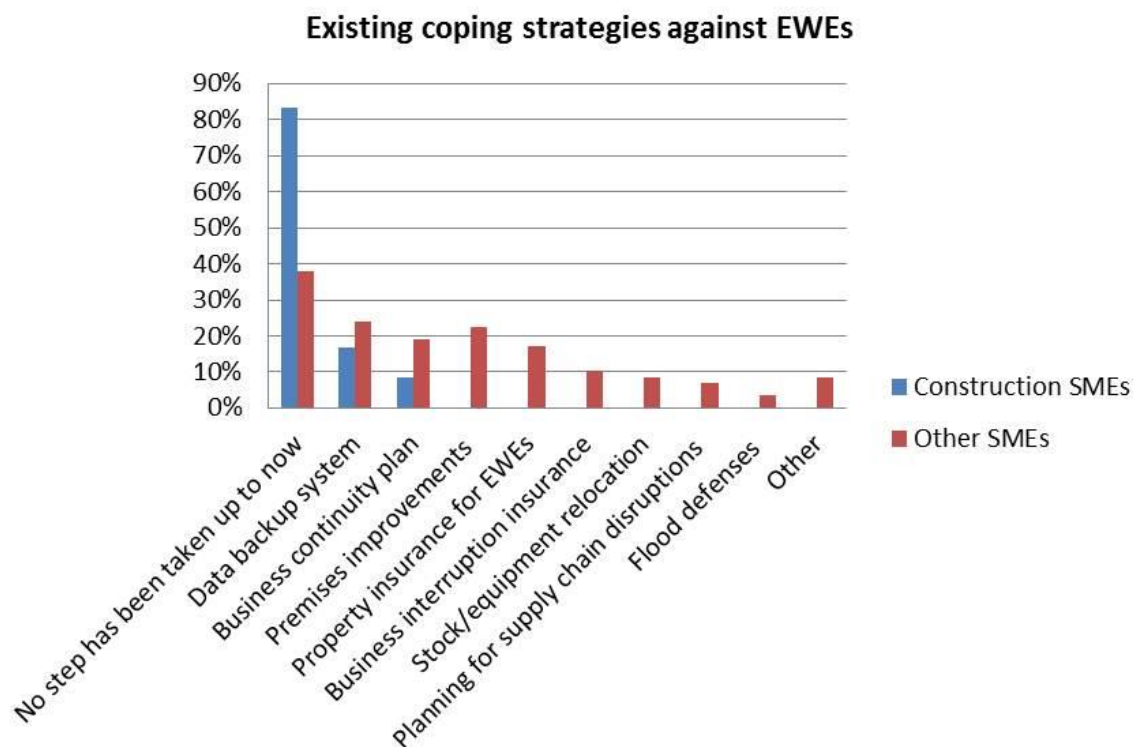


Figure 17 – Existing coping strategies of construction SMEs, in comparison to that of other SMEs

The figures do not vary substantially when the total sample of construction SMEs is considered; irrespective of whether they were affected by EWEs or not (75% - no step has been taken, 12% - property insurance, 12% - business data backup system, 6% - business continuity plan, n=21). It is noteworthy that none of the construction SMEs surveyed had signed up for any early warning system that would provide them with advance warnings of EWEs to enable them to take precautionary measures. The findings suggest that the construction sector SMEs surveyed do not seem to consider EWEs as a potential risk to their business activities. This could be due to the nature of the construction process where disruptions to site practice as a consequence of inclement weather is dealt with at project level rather than at the organisational level. However, figures such as those reported by Wiseman and Parry (2011), where it was reported that 74% of failed businesses following EWEs in 2009 and 2010 in the Cumbrian region were construction

SMEs, creates doubt whether EWE risk is adequately addressed by construction SMEs even at the project level. Further, it also stresses the importance of addressing EWE risk at the organisational level.

A counter argument for the assumption that construction SMEs are likely to address EWE risk in their construction projects would be the fact that this was not mentioned by any of the construction SMEs as an answer to the question. The question had an open ended option where the respondents had the opportunity of inserting any of their coping strategies that were not listed as a choice. This adds weight to the argument that construction SMEs do not seem to consider EWEs as a potential risk to their business activities currently.

4.6 Coping strategies that SMEs may consider in the future

SMEs were questioned on what actions they may consider implementing to address the risk of EWEs in the future. Opting for a business data backup system (10%), developing a business continuity plan (10%), and property insurance (5%) were the only future coping strategies identified by the construction SMEs.

In comparison with construction SMEs, in addition to the actions already implemented, other SMEs were interested in implementing different coping strategies in the future (See Figure 18). The results from the other SME sample (n=119) showed that; property insurance (27%), business data backup system (21%), business continuity plan (16%), premises improvements (16%), business interruption insurance (11%) were found to be the most common coping strategies. The strategies that may be considered in the future included; business data backup system (31%), business continuity plan (24%), property

insurance (22%), business interruption insurance (20%), and premises improvements (12%). These findings, especially considering options like business continuity planning and business interruption insurance, suggest that other SMEs are beginning to realise the negative impacts of EWEs on their business activities and are, increasingly, prepared to consider these in their business decision making. This seems a positive sign, especially considering that the SME sample was not from a locality devastatingly affected by an EWE (for example, as in the case of the study by Wedawatta et al (2012), where the focus was the Cockermouth area which was devastatingly affected by a flood event), but from a catchment area with a higher risk and with moderate experience of EWEs.

This highlights that if the proper information, especially with regard to the risk of EWEs and the benefits of being prepared, is properly conveyed to SMEs they might well implement such coping strategies. A considerable percentage is willing to consider premises improvements and even relocation. Interestingly, not many businesses were prepared to consider signing up for an EWE early warning system. Previous studies (Alesch et al., 2001) have shown that the lead in time required for businesses to take action prior to an event is a factor affecting their ability to respond to and survive an event. Therefore, such strategies could be highly useful to SMEs, especially for construction SMEs.

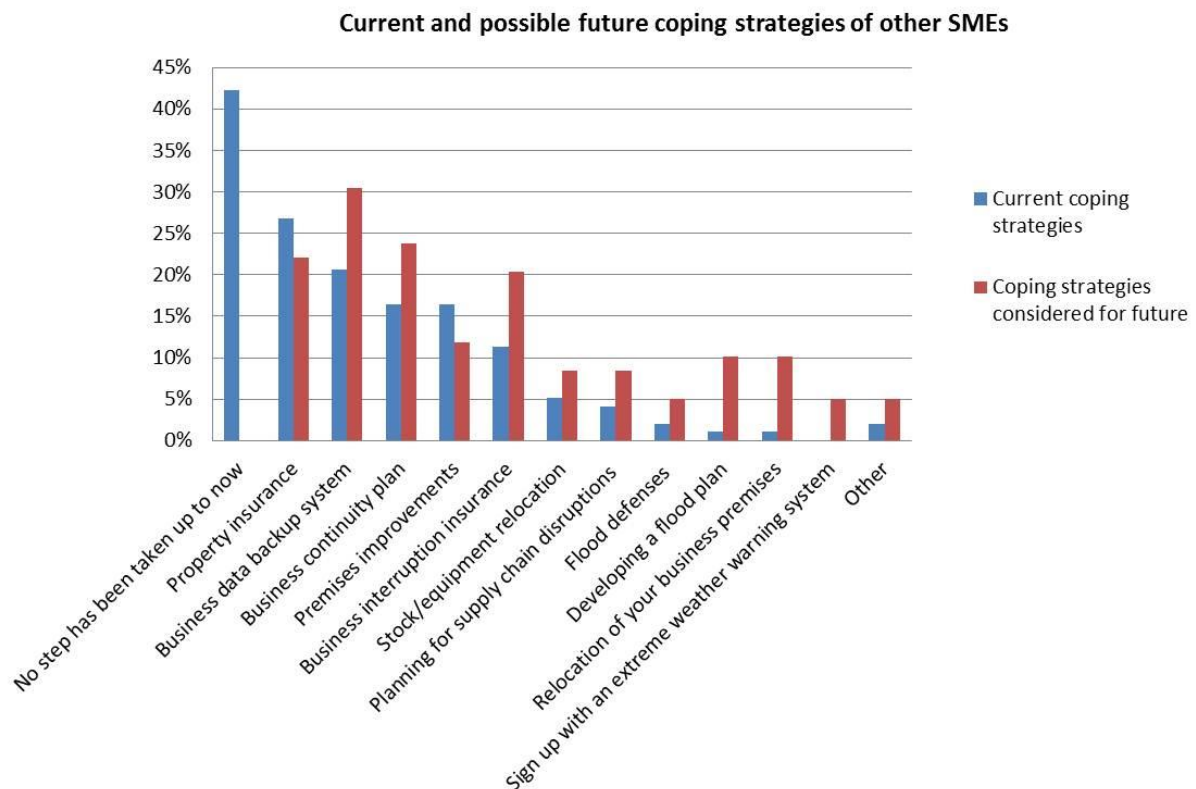


Figure 18 – Current and possible future coping strategies of other SMEs

However, the response of construction SMEs to the increasing risk of EWEs needs to be improved. As evidently established in Sections 2.5 and 2.6, EWEs can cause significant disruptions to construction SMEs, especially when SMEs are caught unprepared. Their lack of preparedness will thus make them more vulnerable to disruptions in the event of an EWE.

This raised further concerns that, in addition to their individual businesses not being prepared to manage the negative consequences of EWEs, the construction sector is not actively engaged in making properties more resilient to EWEs. If the risk is not considered in their individual business decision making process, it is doubtful whether the risk will be considered when designing and constructing buildings. If the SME sector is not positively involved there is less likelihood of policy initiatives to make buildings more resilient to

EWEs (for instance, a shift in policy where communities at risk of flooding are increasingly urged to adapt their properties) being successful.

A study by Emissions Strategy Solutions (2011) for the UKCIP discussed how accountants can be a useful source of advice for SMEs on how to enhance their resilience against EWEs. Further, Wedawatta et al (2012) discussed the even greater role that stakeholders of the construction industry can play in this regard, especially with regard to property-level adaptation of SMEs. However, if the construction sector does not consider the risk of EWEs, their implications and coping strategies in their own business context, it is doubtful whether these issues will be considered in their end products i.e. business premises, etc. Therefore, the current inertia among construction SMEs regarding EWE risk may have wider implications including that for other SMEs, especially in light of policy drivers increasingly urging adaptation.

Lack of initiatives among construction SMEs against the risk of EWEs, and their lack of enthusiasm in implementing such initiatives in the future warrants investigation into the reason behind such lack of action. The next sub section looks at the reasons cited by SMEs for not opting for coping strategies in the face of EWEs.

4.7 Reasons for opting against coping strategies

The SMEs who, to date, have not undertaken any coping strategies and/or have said that they are unlikely to consider future proposals were questioned about the reasons for their decision. Responses from the SME leaders revealed that many either do not foresee EWEs affecting their business in the future (construction SMEs – 33%, other SMEs – 41%) and/or do not consider EWEs as a significant risk to warrant implementation of any

coping strategies (construction SMEs – 33%, other SMEs – 43%) as shown in Figure 19. Common factors identified in previous studies, such as cost, information, and workload were not identified as significant reasons by the SMEs surveyed, in comparison to the main two reasons.

It can be noted that the percentage of construction SMEs that have said that either the risk of EWEs are not significant and/or that they do not contemplate EWEs affecting them in the near future is less than that of other SMEs. Whilst the sample size of construction SMEs restricts the ability to make strong conclusions in this regard, this seems to suggest that construction SMEs are more aware of the risk that EWEs can create on their activities. However, as discussed in Section 2.6.3, they do not seem to consider the risk in their business decision making due to the perception that the risk is addressed in their projects. Therefore, there seems to be the need for enhancing the awareness of construction SMEs in addressing the EWE risk at organisational level.

SME responses to this question further strengthens the argument that they are unlikely to consider EWEs as a significant risk or to consider the risk in their business decision making unless they have had experience of such an event, i.e. a frame of reference to which they can relate the risk, impacts and coping strategies. This situation is similar to that of households, where it was found that experiencing a flood event increases the uptake of flood protection measures by households (Harries, 2008). In the case of businesses, Molino and Gissing (2005) and Kreibich et al (2007) noted an increase in flood preparedness of businesses after being affected by a flood event. Similarly, a study conducted on behalf of Yorkshire Forward (EKOS Consulting (UK) Ltd, 2008) identified increases in flood preparedness activities of businesses affected by flooding. However, as

previous research has shown (see Section 2.5), some of the SMEs that have been affected by an EWE might go out of business following the event and therefore, might not be in a position to consider the risk afterwards.

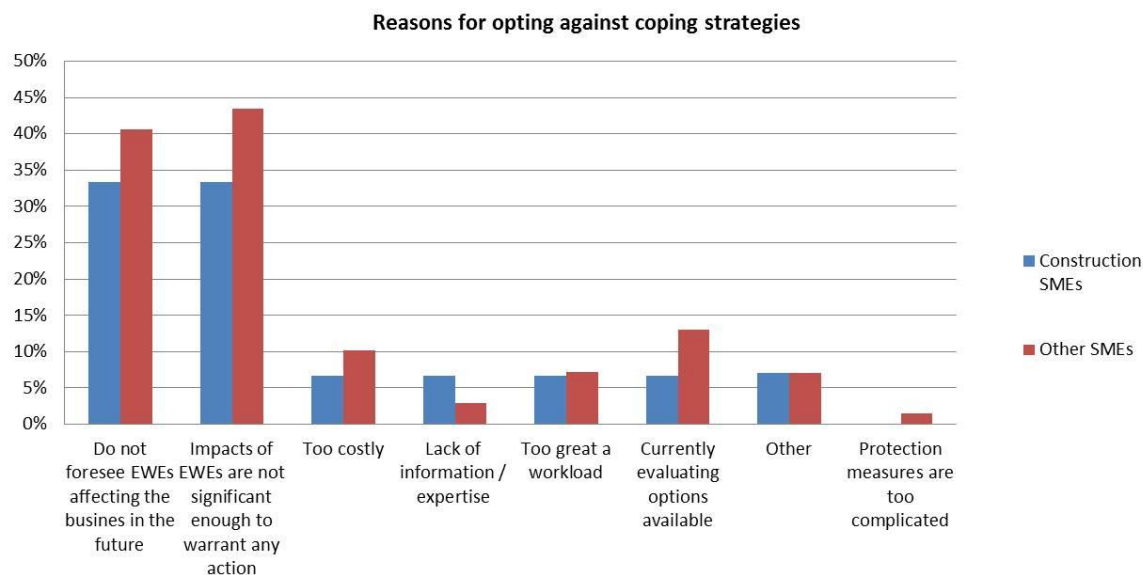


Figure 19 – Reasons for not opting for coping strategies

Findings from the questionnaire survey reveal that practice and policy initiatives aimed at enhancing SMEs resilience to EWEs will have to address the two main perceptions held by the SMEs; 1. EWEs might not affect them in the future, 2. EWEs will not have a significant impact on their business activities.

Uncertainty associated with current EWE projections, lack of awareness of the risk of EWEs in their locality, and not experiencing an EWE before can contribute towards the first perception. Also, the probability of such events has a tendency to mislead business owners and householders alike. Research reports that misunderstanding of probabilistic information among the public in general was high (Lumbroso and Christerson, 2009). Such misconception among SME owners has also been observed by Wedawatta and

Ingirige (2012) and Hallet (2013). For example, SME owners may perceive that being affected by a 1 in 100 flood event in the previous year means that they will not be affected by a similar flood event for another 100 years. However, the estimate is that there is a 1% probability of a similar flood event to that of the last year occurring in any given year. Further, changing climatic conditions are expected to increase the risk of EWEs in the future. For instance, in relation to flooding, Fowler et al (2005) reported that the recent increases in rainfall intensity seen in the UK are consistent with the predicted increases in frequency and intensity of heavy rainfall in the high latitudes of the Northern Hemisphere. As many of the flood events that have affected the UK in recent years were induced by heavy rainfall, increases in the occurrence of such flood events are likely in the future, according to the above mentioned evidence. Further, Evans et al (2004) in Foresight: Future Flooding Report identified urbanisation, environmental regulations, rural land management, increasing national wealth, and social impacts as the main drivers for the increased risk of flooding in the UK in the future, in addition to climate change. The Environment Agency (2009b) highlights the deterioration of assets and continuing pressure to build in areas at risk of flooding as factors contributing towards increasing risk in addition to climate change. This suggests that society is likely to become increasingly vulnerable to flood risk, irrespective of the debate as to whether climate change will increase the intensity and frequency of flooding in the future. Therefore, initiatives aimed at urging communities to adapt need to convey, effectively, the current level of risk and what the future entails for SME owners if they are to realise the risk of EWEs and address the risk within their business planning. It is important that these initiatives are targeted at local level where the risk level is high and warrants such initiatives rather than at national

level. Otherwise, it could also lead to unnecessary costs and further strains on the SME community.

The fact that many SMEs believe that EWEs will not have a critical impact on their business activities highlights the need for making SMEs aware of the potential impacts of EWEs and their consequences. Building up knowledge bases, case studies of EWE impacts and successful adaptation strategies can be useful strategies in this regard. Such case studies can then provide SMEs with a frame of reference, identified by Berkhout et al (2004) as essential if SMEs are to realise the impacts of EWEs and for them to relate to and apply such strategies to their businesses. If such information is to be useful to construction SMEs it is necessary that the case stories are based on the construction industry, so that construction SMEs can readily relate this to their organisations. Currently, case studies specifically focussed on construction SMEs are largely unavailable. The case study stage of this research will contribute towards this gap by documenting two cases of construction SMEs.

4.8 Sources of assistance

SMEs were questioned as to which sources they may expect to receive assistance from if they are affected by an EWE. Insurance company, emergency services and local authority were the most prominent sources identified (See Figure 20). SMEs relying significantly on insurance to recover from EWE related damages is well documented as discussed in the Section 2.5.3. However, their post-event cost of insurance is likely to increase if that is the case. For example, Wedawatta et al (2013) reported how the flood affected SMEs in Cockerthorpe experienced significant increases in their post-flood insurance excess and premiums. Especially with regards to flooding, there is a great deal of uncertainty

surrounding availability and cost of flood insurance for small businesses located in high flood risk areas, as the agreement between the UK government and the Association of British Insurers (ABI) is set to expire in 2013 (ABI, 2008a), and the stance of the insurance industry has been that it will not be renewed after 2013 (ABI, 2012). Therefore, SMEs may not be able to rely on insurance alone in the future.

It should be noted that construction SMEs do not seem to anticipate receiving as much assistance as expected by the other SMEs following an EWE. This issue is worth investigating, as construction SMEs were also found to be much less prepared than other SMEs to cope with the impacts of EWEs. If the risk is dealt with at the project level the costs and impacts of such EWEs will then be passed along the supply chain of construction SMEs; either forward to the client or backwards to subcontractors and suppliers alike. If not, the impacts will be felt by the construction SME whose project is affected by an EWE. Transferring the costs along the supply chain forward to the client may hinder achieving increased client satisfaction in construction projects. These issues will be addressed in detail at the case study stage in order to further investigate how construction SMEs are currently addressing the risk of EWEs.

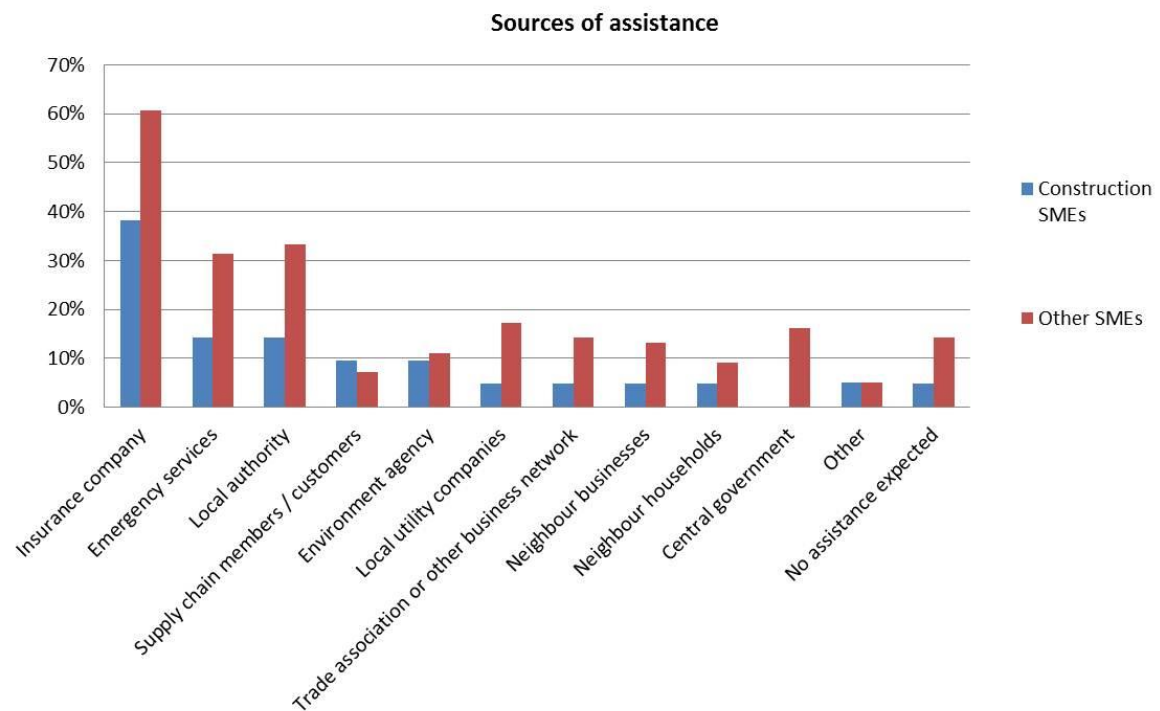


Figure 20 – Sources where SMEs may expect assistance from, following an EWE

4.9 Sources of information on EWEs

SMEs were asked about which sources that they would prefer to receive information about EWE related issues. Information on different sources was gathered using a five-point Likert scale varying from “very good” to “do not know”. A weighting was allocated to each choice, where “very good” = 4, “good” = 3, “acceptable” = 2, “poor” = 1, and “do not know = 0”. Weighted impacts on SMEs were then ranked using the Relative Importance Index (RII) method. Ranking of different sources is shown in Table 13.

Table 13 – Ranking of sources preferred by construction SME for EWE information

Source	No of responses with highest weight	No of responses with lowest weight	Mean weight	RII	Rank based on RII
Television	5	1	3.27	0.82	1
Met office announcements	3	2	2.93	0.73	2
Internet	5	3	2.85	0.71	3
Newspapers	0	3	2.46	0.62	4
Word of mouth	0	3	1.91	0.48	5
EWE warning system	1	7	0.33	0.33	6
Trade association / business network	0	8	0.73	0.18	7
Local authority	0	7	0.73	0.18	8
Environment agency	0	10	0.27	0.07	9
Seminar / meeting / workshop	0	9	0.27	0.07	10

Accordingly, it can be seen that construction SMEs prefer television, met office announcements, internet and newspapers as sources of information regarding EWEs. It is worth investigating the websites commonly accessed by construction SMEs for such advice. It has to be noted that the Environment Agency (which currently issues flood warnings) and EWE warning systems were allocated a lesser significance comparatively. Other SMEs also ranked the top five choices in the same order as construction SMEs, but the Environment Agency was ranked 6th followed by the EWE warning systems placed 7th. This information is important as it suggests the possible sources from where to disseminate EWE related advice to construction SMEs.

4.10 Potential for relocating their business premises due to EWE risk

In order to determine how serious SMEs consider EWEs are when selecting the location of their business premises, it was asked what the potential was for relocating their premises using different EWE scenarios. For this purpose, flooding was the risk used to represent

EWEs, as flooding is a risk that is localised and also has a significant risk profile in the UK. Accordingly three scenarios were presented; premises are flooded once every two years (50% annual probability of flooding), once every five years (20% annual probability), and once every 10 years (10% annual probability). These time frames were selected as SMEs are often associated with shorter strategic planning horizons. For example, Stonehouse and Pemberton (2002) found that only one fifth of SMEs plan over a five-year time horizon, whereas over 70 per cent of organisations have a planning horizon of three years or less with over one fifth having only a one year planning horizon in the services and manufacturing sectors (Stonehouse and Pemberton, 2002). As noted by Sexton et al (2006) small construction companies generally operate with a very short strategic horizon. Sexton et al (2006) identified this as approximately six months. Soetanto et al (2007) found that 56% of construction SMEs had a strategic plan for the next 5 years. 12% were found to have a strategic horizon of 3 years and only 18% were found to have a horizon of 10 years (Soetanto et al., 2007). Therefore, the scenarios presented were deemed appropriate.

Information on the likelihood of relocation was gathered using a five point Likert scale varying from “very high” to “not at all”. A weighting was allocated to each choice, where “very high” = 4, “high” = 3, “somewhat” = 2, “little” = 1, and “not at all” = 0. Mean scores for each of the scenarios is listed in Table 14. Accordingly, it can be seen that other SMEs are more likely to relocate their business premises when different flooding scenarios were presented to them. This seems to suggest that the risk of EWE risk in the locality in which their premises are located is less important to construction SMEs than other SMEs. Therefore, the case studies of construction SMEs will also investigate EWEs in relation to

construction projects, although the main focus of the study is on construction SMEs at organisational level.

Table 14 – Likelihood of relocating under different flooding scenarios

Scenario	Construction SMEs Mean score	Other SMEs Mean score
Business is flooded once every two years	2.08	2.84
Business is flooded once every five years	1.85	2.22
Business is flooded once every ten years	1.46	1.58

The responses of construction SMEs to this question and to those addressing coping strategies suggest that very little attention is paid by construction SMEs to EWEs at organisational level. However, it has to be noted that business premises affected by EWEs have the potential of creating adverse impacts on any SME, irrespective of the industry sector. For example, loss of business records due to flooding, or employees not being able to report for work due to heavy snowfall can be considered situations in which if the risk is not considered at organisational level the SME concerned is likely to experience negative impacts. It is important that the need for considering EWE risk at organisational level is conveyed to construction SMEs, in order to minimise the negative consequences for construction SMEs and to minimise business closures as reported by McWilliams (2009) and Wiseman and Parry (2011).

4.11 Summary of exploratory questionnaire survey and link

Whilst many of the construction SMEs have experienced the negative effects of EWEs, not many of them have implemented coping strategies or are likely to consider the risk in the future. It is noteworthy that a considerable number of the other SMEs surveyed have

opted for strategies such as business data backup systems and more are willing to implement them in the future. What is required is a concentrated effort on SMEs to make them aware of the risks of EWEs, the coping strategies available, the benefits of coping strategies, and detriments of not implementing them. In the case of construction SMEs, as noted by Revell and Blackburn (2007), many owner-managers of construction SMEs remain unconvinced that there is a legitimate business case for reducing their environmental impacts and have a low level of awareness about environmental issues. This state of affairs could be replicated with regard to EWEs, and thus, a concerted effort, as mentioned above, has the potential of making construction SMEs realise the threat of EWEs.

Further, none of the construction SMEs; indeed none of the SMEs surveyed, identified any positive effects in relation to the EWEs that affected them. This is opposed to the many business opportunities presented by EWEs, especially to the construction sector. Therefore, it seems there is scope to integrate advice on utilising the business opportunities presented by EWEs, along with the EWE risk management awareness initiatives, thus making them more compelling to construction SMEs, i.e. convincing them of the business case for resilience.

The findings of the questionnaire survey have implications for policy makers, the insurance industry, business support organisations and other organisations involved in SME policy and practice. As SMEs are key for regional economic revival, regional policy makers such as local councils; especially those in high risk areas have to be actively involved in making sure that SMEs are better prepared for the potential risk of EWEs

affecting their localities. Findings of the survey emphasise the role of stakeholders assisting SMEs to make better business decisions with regard to the risk of EWE.

The questionnaire survey of construction and other SMEs partially answered the research questions of;

- How do EWEs affect the activities of construction SMEs? (Section 4.4)
- How do construction SMEs perceive the risk of EWEs and their impacts? (Sections 4.4 to 4.6)
- How do construction SMEs currently cope with the effects of EWEs on them, and why do they/why do not they implement coping measures? (Sections 4.5 and 4.7)
- What are the factors that determine the resilience of construction SMEs to EWEs and how to improve their resilience to EWEs? (Section 4.5, coping strategies of other SMEs)
- Can a decision making framework be developed to help construction SMEs to assess the risk of EWEs on their businesses? (Analysis in Sections 4.5, 4.8 - 4.11)

Further, the questionnaire survey also raised further questions for clarification at the next stages of the research including:

- How do construction SMEs currently address the risk of EWEs in their construction projects?

These issues will be further investigated during the next phase of the research; case studies of construction SMEs. Accordingly, in-depth case studies were conducted with two construction SMEs selected through purposive sampling. The next chapter presents the findings of these in-depth case studies.

5 CHAPTER 5 – CASE STUDIES OF CONSTRUCTION SMEs

The findings of the exploratory questionnaire survey were discussed in the previous chapter (Chapter 4). Those discussions partially answered some of the research questions raised for this research study. The case study stage sought to further investigate these issues, and to clarify some of the issues identified during the questionnaire survey stage. Accordingly, semi-structured interviews and extended structured interviews were conducted with personnel from the selected case study organisations. Findings from the case study research stage are detailed in this section. First, the findings from the first case study SME (CSA) are detailed, followed by a description of case study SME2 (CSB).

5.1 Case study 1

As identified in Section 3.7.1.2, the first case study organisation (CSA) is a medium-sized construction company. The findings from the interviews conducted with the respondents from CSA are described in the following sub sections.

5.1.1 Background to the organisation

CSA is a privately (family) owned construction organisation primarily operating across the North West of England. CSA is an established construction SME with a 40 year history. Although their primary focus is on residential and commercial building construction, CSA provide construction services across a number of sectors including health and education, hotel and leisure, commercial and industrial, residential and community. CSA, primarily, acts as a principal contractor in the projects that it undertakes. CSA has an employee base of 76 and an annual turnover of £20million (approximately), and therefore is classed as a

medium-sized business (see Section 2.4.1). CSA directly employs many of its site staff, minimising the need for sub-contracting for labour.

CSA has an integrated management system with a limited number of layers within the organisational hierarchy, and therefore, a short management chain within the organisation. It has a central decision making structure, where strategic and significant operational decisions are made directly by the senior management, consisting of the managing director, operations director and commercial director (See Appendix-L for the organisational structure of CSA). Due to the nature of the decision making structure within the organisation, the commercial director (CSA1) was selected as the appropriate resource person to interview.

5.1.1.1 Case study informant (organisational)

CSA1; the commercial director of CSA, is a construction professional with about 25 years of industry experience. CSA1 began his career as a quantity surveyor, moving up through the ranks to become the commercial director of the organisation. CSA1 is directly responsible for the strategic growth of the business and all aspects of project delivery. An initial semi-structured interview (See Appendix – E for semi-structured interview template) with CSA1 was followed by an extended structured interview (See Appendix – F for extended interview template) for the purpose of completing the risk assessment. The interview transcripts were then reviewed by CSA1 to check whether the transcripts accurately reflect the views expressed.

5.1.1.2 Selected construction project

Although the primary focus of the study is at organisational level, it was decided that construction projects should be part of the study, following the findings of the questionnaire survey. As it was noted that construction SMEs seldom address the risk of EWEs in their organisational planning, it was necessary to investigate how the overall risk is addressed for construction projects, and how this affects the organisation. The CSA project selected for this purpose was a residential construction project (CSAP) in progress at the time the interview was conducted. CSAP was a luxury detached house constructed by CSA. CSAP had a contract value of approximately £2 million and project duration of 60 weeks. The project was awarded to CSA following open tendering with a Bill of Quantities (BoQ). The project manager of CSAP (CSAP1) was interviewed to gather information in regard to the project. CSA1 was an experienced professional who has been in the industry for over 30 years. The project manager was the person responsible for delivery of the project on behalf of CSA, and was reported directly to CSA1 at the head office.

5.1.2 Previous experience of EWEs

Previous experiences of EWEs were coded in NVivo as shown in Figure 21, to facilitate analysis of the perspective of SMEs to the EWEs that had affected them and to facilitate cross-analysis. According to CSA1, the activities of CSA have been affected by EWEs several times in the recent past prior to the interviews being conducted. These included heavy snowfall, heavy rainfall, and extreme low temperatures. It has, in the past been affected by flooding, but not recently (within the 5 years prior to the interview being conducted). CSA1 noted *“Recently, during late December, all of January and the first week of February, a significant drop in temperature affected our physical ability to complete*

wet trades. That started happening around December time for us, and then the snow kicked in”.

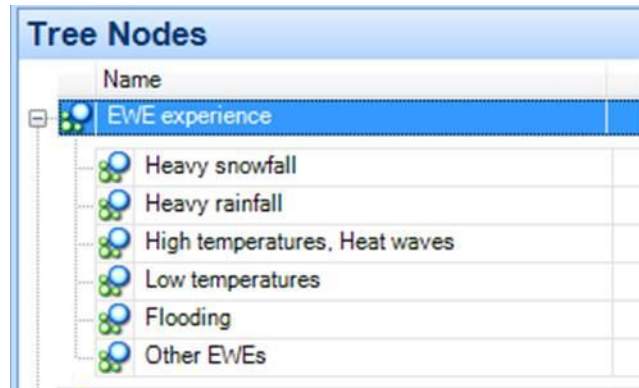


Figure 21 – Coding structure for EWEs experienced

The project from CSA that was selected for the study was one that was significantly affected by EWEs as identified above. According to CSAP1, the project was affected by low temperatures and heavy snowfall during January – February 2010. As the case studies were conducted between May – July 2010, much of the discussions about EWEs with respondents from CSA were based on heavy snowfall and low temperatures. CSA had also experienced disruptions associated with these EWEs the year before, during January – February 2009. However, it has to be noted that the focus of discussions with CSA1 was mostly centred on the EWE experiences of early 2010, suggesting that SME decision makers are likely to be concerned about EWEs that affected them most recently. Further, this also suggests that concern of SME decision makers on a particular EWE is likely to be temporary and is subject to change when affected by another EWE. Therefore, any decision taken on EWEs is likely to be focused on the particular EWEs that are of concern at that time, rather than strategically, on EWEs as a whole. For instance, although CSA has

seen its business activities affected by flooding during the past, its concern over flooding at the time of interview was limited due to not having any recent experiences.

5.1.3 Impacts of EWEs

5.1.3.1 Impacts on CSA

Transcripts of interview with CSA1 and CSAP1 were coded for the impacts experienced due to the recent EWEs experienced (See Figure 22). Much of the impacts on CSA have stemmed from not being able to carry out activities on the projects that were under construction at the time. As noted in the previous section (Section 5.1.2), the construction projects operated by CSA have been affected by EWEs for an elongated period at the start of the 2010. As noted by CSA1, site activities were affected for over 6 weeks during that time. CSA1 noted; *“a significant drop in temperature affected the ability to complete wet trades; brick work, block work. When it gets below freezing you cannot lay bricks or blocks. Then snow affected our external ground works on a number of sites; on housing and schools projects. We were struggling because of the weather, to get access to work zones and undertake any work whatsoever on a number of sites. That affected 90% of the business or the workload”*. Not being able to conduct construction work on most of its construction projects created a number of financial problems for CSA including loss of revenue, additional costs, negative effect on cash flow, and loss of profit. Chan and Au (2007) identified some of the costs involved with EWE disruptions; expenses in special planning and scheduling of works, accelerating works with more labour input, and the risk of being required to pay liquidated damages.

Other major issues mentioned included travel difficulties for employees, and termination of businesses in the supply chain. It was mentioned by CSA1 that one of the roofing sub-contractors with whom CSA had had a long partnership ceased to operate following the EWEs. It was noted that its survival was hampered by the inability to conduct roofing work for a prolonged time and the loss of revenue as a result. This had a knock-on effect on CSA, who had to establish links with other roofing sub-contractors and replace the insolvent sub-contractor on existing projects.

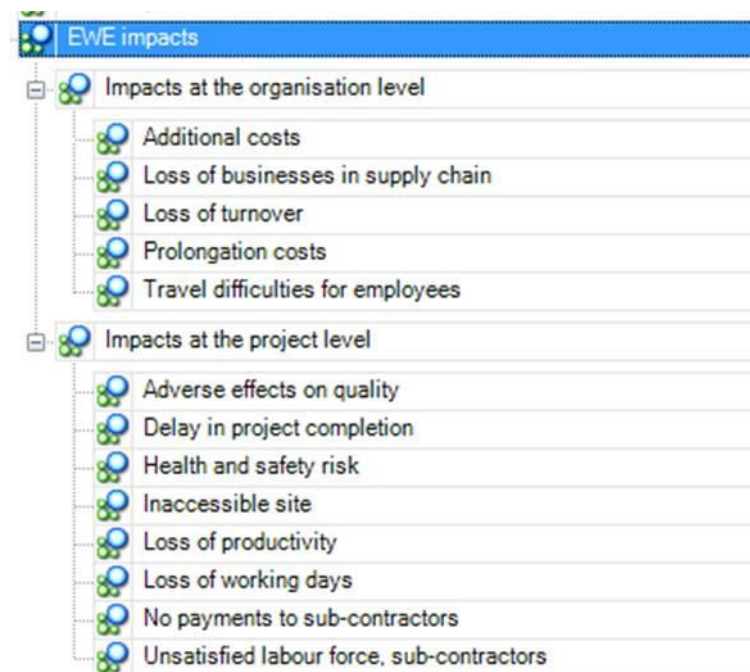


Figure 22 - Coding structure of impacts of EWEs on CSA and CSAP

5.1.3.2 Impacts on CSAP

On the project studied, CSAP had been affected by low temperatures and heavy snowfall during January – February 2010, as mentioned in Section 5.1.2. Information from site records showed that the disruptions lasted for over 6 weeks. CSAP1 noted that loss of work due to EWEs for a long period following the Christmas break resulted in an extension of project duration, additional costs, reduction in quality of work, health and

safety risk to employees, sub-contractors and suppliers not receiving payments, and dissatisfied client, employees and sub-contractors. CSAP1 noted, *"It was a waste of time and money, men coming to work but not getting paid because of no work, they lost money and we lost money. I am here and my assistants are here, but nobody is building and they do not get paid, which affects them financially, and they are disappointed. It is a disaster for us when it snows or gets very cold."* CSA received a time extension to complete the project due to the disruption caused by EWEs. However, no additional payments were made to CSA1 for the period affected by EWEs. For example, it was noted that CSA continued to incur costs associated with time related preliminaries during the EWE, but these were not paid back to CSA due to the contractual arrangement of the project. The company's policy and terms of employment allows CSA1 to make directly employed labourers temporarily redundant during extended periods of disruption; and with much of the work on the project being implemented by sub-contractors CSA has been able to reduce the costs to the company significantly. But this has led to an unsatisfied labour force and sub-contractors who did not have any work and thus were not paid for a considerable period following the Christmas break.

CSAP1 noted that elongated disruptions, due to EWEs, leads to an unsatisfied labour force, sub-contractors and suppliers. According to CSAP1, this also affects retention of sub-contractors. In response to a question on employee / sub-contractor retention during EWE periods, CSAP1 noted that *"yes, that has happened, they would say "okay we are not working here, because it is too cold and there is no work, and we have another job down the road where we are inside and we will go there" and they disappear, that is just an example. But even if I knew the weather was going to be bad for two months, then I would*

expect them to go somewhere else to work. But the problem is they might like it there, and might stay and I am stuck. It has not happened to me here but in the past I have known that to happen". This suggests the broader nature of impacts associated with EWEs, in addition to direct tangible impacts such as loss of income.

5.1.3.3 Synthesis of EWE impacts

As discussed above, CSA has experienced a range of impacts on its business due to recent EWEs. These are presented in the form of a cognitive map in Figure 23. A significant majority of these have originated from their construction projects affected by EWEs. This highlights how construction SMEs differ from general SMEs, in relation to EWE impacts. Whereas impacts concerning business premises is portentously significant for sectors like retail, hotels and restaurants, real estate etc as well as consultancy practices in construction such as Quantity Surveying and Architectural practices (Wedawatta and Ingirige, 2012; Wedawatta et al., 2012), for construction SMEs the focus is on their construction projects.

Loss of income for a prolonged period was highlighted as the major impact experienced by CSA as a result of EWEs. Although loss of time has been reclaimed via time extensions, the business has not been managed to recover from the loss of income during that period. CSA has managed to reduce the extent of some of the impacts due to their existing coping strategies and coping capacity. These are discussed in Section 5.1.5. Loss of income coupled with additional costs can critically affect the cash flow of construction SMEs. For example, CSA1 noted that *"we will normally look for a turn-over in business activities of may be 1.5million pounds a month for construction activities. So we would expect to raise invoices circa 1.5 million pounds every month over a 12 month period. I*

would say in that period we turned over may be £300,000, - 400,000. That is massive. If that is sustained for 2 months it could send you out of business". This suggests the reason why construction SMEs were found to be the sector which reported the highest number of business closures following EWEs; as noted by Wiseman and Parry (2011). This was confirmed by CSA1, with the statement that *"if you draw a graph to see how many construction companies went out of business, there will definitely be a correlation this year between the number going out of business, the weather, and the time of the year"*.

As identified in the previous comment from CSA1, the time period in which the EWEs affected CSA was also identified as critical. The EWEs that CSA was mostly concerned about occurred just after the Christmas break. As noted by CSAP1, *"we shut down for 2 weeks over the Christmas period, but the period after we returned was the major time of the extreme weather"*. As the business had already been closed for Christmas for 2 weeks and had not generated an income over that period, any additional disruptions were noted as being extremely damaging. EWE disruptions that continued for around 6 weeks meant that the total time lost was an 8 week stretch. CSA1 commented that *"if you take in to account the time of the year, in the construction industry what traditionally happens is that there is a 2 week Christmas break. So you have got 2 weeks Christmas break, loss of productivity before Christmas, and after Christmas. And you have got the low profit margins driven by the economic climate"*. This suggests that the time of the year when the EWE strikes and the duration of the EWE can play a crucial role in determining the extent of the impact on a business.

The evidence also suggested that EWEs could affect the key success criteria for delivery of a construction project; time, cost and quality. The impact on time and cost were

discussed in detail above. As noted by CSAP1, EWEs could also affect the quality of construction work. For instance, it was noted that carrying out activities such as brick work, block work, ground works and in-situ concrete work at low temperatures can affect the quality of work done. Therefore it can be noted that EWEs have the potential to negatively affect the primary success criteria for delivery of a construction project, thereby creating a plethora of impacts on a construction SMEs, especially for the main contractor.

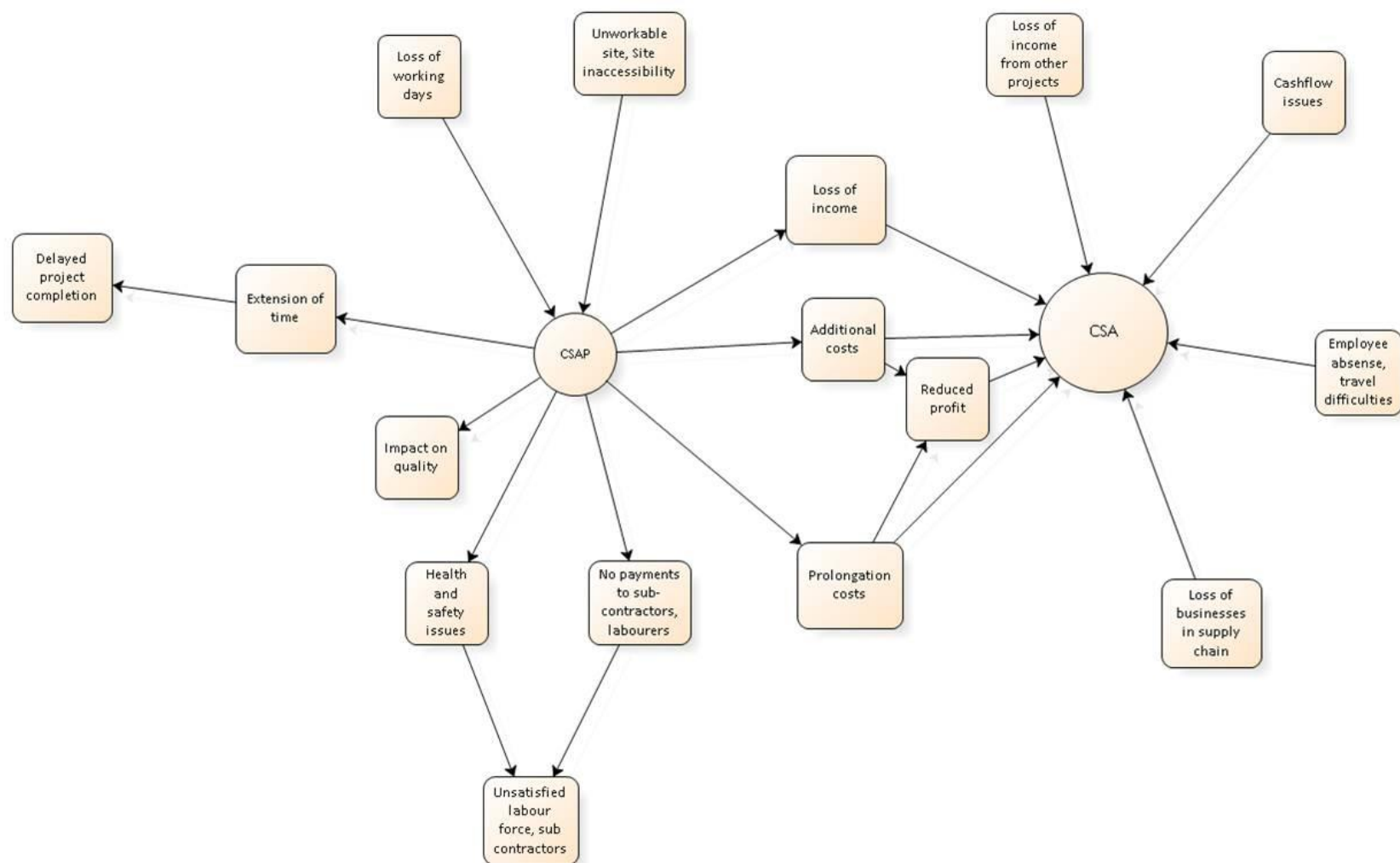


Figure 23 - Cognitive map of impacts of EWEs on CSA

5.1.4 EWEs as a critical risk

The results of the exploratory questionnaire survey revealed that construction SMEs do not seem to consider EWEs as a significant risk to their businesses (see Section 4.7). This was cited as one of the main reasons for opting against implementing coping strategies against EWEs. In order to further investigate this aspect, case study informants were questioned as to whether they consider EWEs to be a critical risk to their business activities.

As opposed to questionnaire survey informants, CSA1 considered EWEs to be a critical risk to its business activities. According to CSA1, criticality of the risk was seen as linked to business survival, and therefore impacts of EWEs that can threaten the survival of a SME were recognised as critical issues. Primarily, financial problems that can be caused by EWEs were seen as critical for business survival, especially in the current economic climate. CSA1 noted that the financial risk of a construction project mainly rests on the main contractor. As CSA primarily undertake work as the main contractor, the financial risk undertaken by CSA was seen as “massive”. EWEs were seen to be a critical risk that can cause significant financial issues to the business. A cognitive map of the possible impact of EWEs on a construction SME and why the risk can critically affect the survival of a construction SME is shown in Figure 24. Note that this is different from Figure 23, in which the effects experienced by CSA in relation to recent EWEs were depicted. Figure 24 is a representation of how CSA1 perceives EWEs can affect a construction SME. According to CSA1, EWEs are a critical risk as they can severely affect the financial situation of a construction SME, even leading to business failure.

Problems relating to workforce, customers, markets and supply chain were identified as contributory, but not critical, business risks that can send a construction SME out of business. EWEs affecting business premises was not seen as a significant risk to construction SMEs, as business premises were not regarded as significant when compared to construction projects as discussed in Section 5.1.3.3.

CSA1 noted that the current economic climate has also contributed to EWEs being a critical business risk. It was mentioned that as construction SMEs operate with lower profit margins and tighter budgets, even minor disruptions can cause significant financial difficulties. It was noted that such minor disruptions might not have mattered if the economic climate was healthy and favourable. Therefore, the economic climate was identified as a factor that has contributed to EWEs being perceived as a critical risk during recent years.

Both CSA1 and CSAP1 highlighted the fact that specialist sub-contractors like SMEs operating in roofing work, ground work, and wet trades including brick work, block work and concrete work were some of the trades significantly disturbed by EWE disruptions including heavy snowfall and low temperatures that affected much of the UK. This again was primarily due to not being able to undertake work for a prolonged period and thus not being able to generate income during that period. Accordingly, the business area or the specialism was highlighted as a factor contributing to whether the EWE is a critical risk or not.

CSA has survived the experience of back to back EWEs that have created a significant impact on CSA during 2009 and 2010 prior to when the case study was conducted.

Experiencing significant EWE impacts has made CSA aware of how EWEs can affect its business. Therefore, the business is now concerned about the risk of EWEs, but it has to be seen whether experiencing EWEs, and realising the threat to business, has resulted in CSA developing strategies to manage the risk of EWEs. The next section discusses the existing risk management strategies that were thought to be contributing towards the resilience of CSA to EWEs.

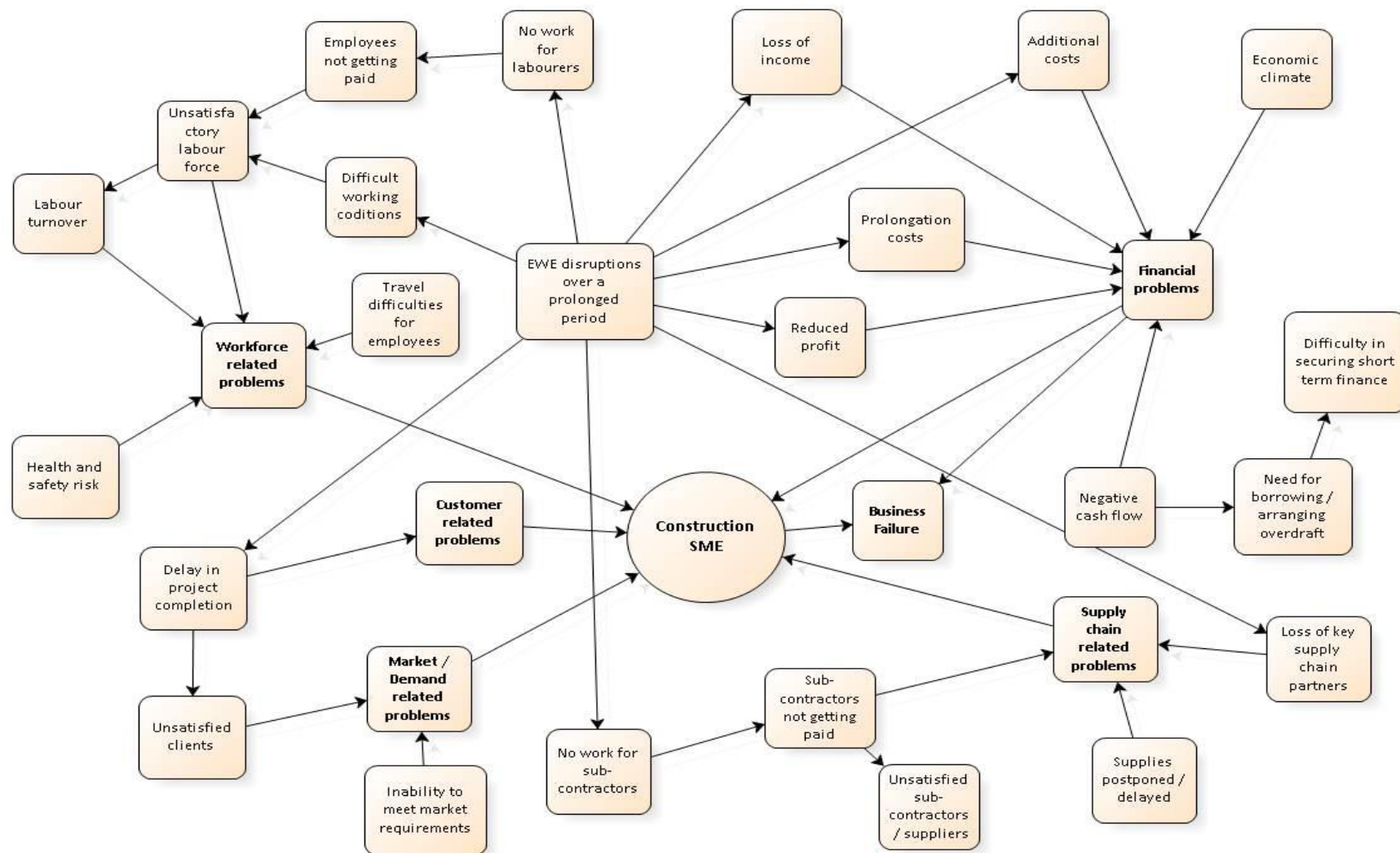


Figure 24 – EWEs as a critical business risk – perception of CSA

5.1.5 Existing risk management strategies against EWEs

Semi-structured interviews conducted with CSA1 and CSAP1 investigated how the risk of EWEs is currently addressed within CSA and its projects. The extended interview conducted with CSA1 threw further light on these measures and a number of additional measures were revealed. These were coded under different categories as shown in Figure 25. It has to be noted that whilst some of the measures (e.g. pricing strategies) are specific strategies to reduce the impacts of EWEs, some were general risk management strategies (e.g. terms of employment, business continuity plan) that have helped CSA to manage the impacts of recent EWEs.

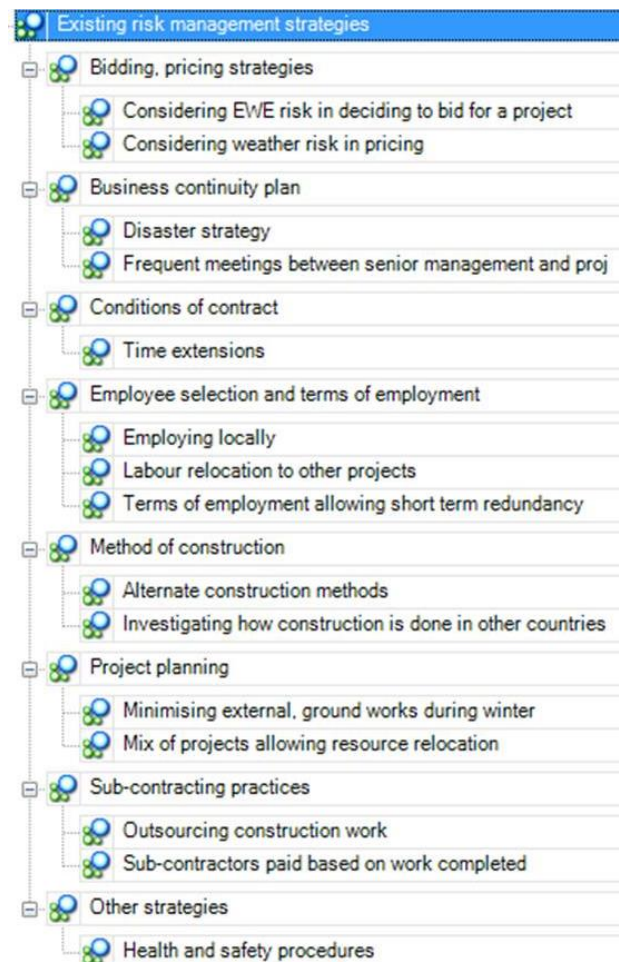


Figure 25 – Coding structure of how the EWE risk is currently addressed in CSA

5.1.5.1 Estimating and Bidding strategies

It was mentioned by CSA1 that EWEs are now considered when making decisions on whether to bid for a project, and if so, on the prices quoted. It was mentioned by CSA that weather is considered to be a factor when evaluating whether a project is attractive to the business and whether to bid for that project. For example, CSA mentioned that a project for excavating a basement during the winter might not be considered viable to bid for. Answering a question as to whether the risks of EWEs are factored in when pricing a tender for a project, CSA replied that *“yes we have to. That dictates how you build as well, your building methodology”*. Methods of construction are discussed separately, in Section 5.1.5.3. In relation to pricing and weather conditions, it was noted that *“sometimes you do not appreciate how regional these weather conditions are, there will be a difference in how quickly something can be built in Central London, in Manchester and in Scotland for example”*.

Whilst the line of inquiry was about EWEs, the response of CSA in relation to pricing and bidding suggested that what contractors seem to consider in making such decisions is weather rather than EWEs. As Laryea and Hughes (2008) noted, weather is one of the major risks that contractors consider when pricing bids. However, Chan and Au (2007) noted that the pricing behaviour pertaining to weather risk varies among contractors of different sizes and that smaller contractors are more willing to absorb weather risks in tenders. This evidence suggests that construction SMEs consider weather risk when making bidding decisions, albeit to a lesser extent than larger construction companies. However, it is doubtful whether the same attention is paid towards EWEs. For example, as mentioned by CSA1 and CSAP1, factors like whether some construction activities are

conducted during the winter months, and if so, the likely national and regional weather conditions are considered in making pricing and bidding decisions. From the discussion with CSA1, it could be identified that up to now this has been an assessment of general weather conditions during the winter and in that particular region, rather than an assessment of EWEs that could occur during the winter in that region. However, following their experience of back to back EWEs during recent winter months, CSA has now started to consider the risk of EWEs during the winter, primarily due to the significant impacts encountered by CSA. However, this consideration does not seem to have expanded to cover a broad range of possible EWEs, outside what has experienced during recent years.

5.1.5.2 Project planning

It was mentioned by CSA1 that one of the strategies implemented by CSA was to plan project activities making use of a mixture of indoor and outdoor activities on their different projects at any given time, so that employees can be re-assigned to projects which are not affected by weather, if a particular project is affected for a long time period. It was noted by CSA1 that *“we have been more selective about the type of work we do in the seasons. What we could have done is to relocate, redistributing our workforce to projects that are not affected. Subconsciously what we are trying to do is to get a good mix of jobs so that you can put your tradesmen in to those jobs. What I am saying is that we have to be mindful of the type of work we do and have a diverse range of both indoor and outdoor work”*. However, it was also mentioned that relocating the workforce was difficult during the EWEs in 2009 and 2010, as the activities of most of the projects were disrupted by heavy snowfall and low temperatures.

It was also noted that following the experience of back to back winter EWE experiences, CSA is now planning its project activities more carefully to minimise vulnerable site activities during the winter. For instance it was mentioned that it would refrain from attempting to schedule basement excavations during the months of January – February. This follows the experience of basement excavations being filled with snow and incurring additional costs as a result in a couple of projects in the past year. It was recognised by CSA1 that; *“it was a wakeup call for us to think about when we dig basements, if you are going to excavate a basement in the winter you are going to be subjected to flooding (due to snowfall), you are going to incur the cost of trying to dewater. It puts people’s lives at risk working there as well”*.

5.1.5.3 Methods of construction

It was noted by interviewees from CSA that addressing weather risks in methods of construction was a strategy used by construction companies. It was stated by CSA1 that *“we thought about the method of construction. We started looking at timber frame construction in our new-build work. In Scotland, to compensate for bad weather affecting construction, they go for timber frame construction. It is quicker, it is less affected by the weather, and they get to roof level quicker than traditional construction. So I think a lot of houses are timber frame”*, suggesting that CSA is now considering EWE risk in their method of construction.

It was stated that CSA has started investigating construction practices in countries where the EWEs experienced in the UK during the 2009 and 2010 winters are the norm, and therefore rather common. It was mentioned that *“if you look at countries like Canada, they work through these severe weather conditions in Canada and they still build and they*

still go to work". The need for making construction SMEs in the UK aware of such practices was also highlighted in light of the EWEs that affected the UK. In addition to minimising negative consequences, CSA1 considered that adapting such practices would provide the company with a competitive edge over its rivals, due to being able to provide clients with a better output.

5.1.5.4 Business continuity plan

CSA has a business continuity plan in place, outlining the roles and responsibilities of personnel, procedures to be followed during times of disruption such as during EWEs. However, inspection of the business continuity plan of CSA revealed that EWEs have not been specifically considered in developing the plan. The plan has been developed for continuity of business in general, but having such a plan in place has enabled CSA to respond to EWE disruptions in a more organised manner. For example, it was pointed out by CSA1 that the BCP includes guidelines on the decision making process to be followed in the event of a disruption, roles and responsibilities of personnel and the communication process to follow. Accordingly, frequent meetings between senior management and site management are underlined as an action to be taken if the site activities are affected by a particular issue. CSA1 noted *"it results in a meeting among co-directors to talk about work distribution and to engage the human resource staff to make sure that everyone is communicating and knows what is happening and keep them informed during that period, and it is critical to be kept informed"*.

From a construction project perspective, CSAP1 pointed out that one of his duties during crucial times was to have frequent meetings with senior management at head office; CSA1, was to provide necessary information and enter in to agreement over what actions

should be taken. Whilst the BCP of CSA has not addressed EWEs specifically, it can be seen that having a general planning mechanism to respond to any disruptive event has allowed CSA to respond to EWEs in an effective way.

5.1.5.5 Employee selection and terms of labour employment

Following the shrinkage of construction activities amidst the current recession prevailing in the UK economy, CSA has re-assessed some of its practices. CSA has changed the terms of employment for its direct labour force, allowing CSA to temporarily lay off staff during periods of low construction activity. Whilst this step has not been implemented in relation to the risk of EWEs, this provision has allowed CSA to temporarily make some of the site staff redundant during any period affected by EWEs. This has allowed CSA to considerably reduce expenses during the times when construction activities do not take place. CSA1 noted *“had we not changed our contracts a few years ago, we would have had to absorb that cost as a business”*. However, CSA1 identified that this demoralised the employees involved as they were out of work just after the Christmas break; *“that was really difficult for those guys. It was a difficult time just after the Christmas break”*. Therefore, it was recognised that whilst the measure has contributed towards lower costs and less negative effect on the cash flow of CSA, it had affected labourers employed by CSA.

It was stated by CSA1 that it attempts to employ locally on their projects and that this has helped to minimise the impacts of travel disruption caused by EWEs. CSA1 noted *“we try to employ locally. We are mindful of that from an environmental point of view and cost. We try to keep people in close proximity to where they come from wherever we can”*. This has also enabled CSA to commence or stop work at construction sites with short notice to

site staff, as the travelling durations are kept to a minimum. Head office staff that were unable to report to work due to EWEs was identified as an issue experienced by CSA. However in relation to projects, it was mentioned by both CSAP1 and CSA1 that the problem with the EWEs that were experienced during the recent past was being unable to conduct site activities rather than employees not being able to report for work. It was mentioned by CSAP1 that, having reported for work, labourers had to wait for hours to see whether the situation would improve and then return home without have done any work for a number of days.

5.1.5.6 Sub-contracting practices

Sub-contracting practices where particular work sections are awarded to sub-contractors was identified as a strategy where the risk of disruption is transferred to sub-contractors. As CSA primarily carries out work as the principal contractor, it was pointed out that this has enabled CSA to transfer some of the costs associated with EWEs to its sub-contractors, such as brick laying, ground work and roofing sub-contractors. It was mentioned by CSA1 that *“I think risk cascades down supply chains. We pass that risk down to the sub-contractors. So when we get rates from sub-contractors it will be a rate for laying bricks, not for a period of time. And the reason for doing that is because then he takes the risk, if it takes longer than specified he takes the risk and we pay for actual physical work. So it is transferred down the line and you can imagine that if you talk to bricklaying subcontractors and ground workers I think they were severely affected by this, because the risks are transferred down the line”*.

However, it was also suggested that this could have a detrimental impact on such sub-contractors, as pointed out by CSA1 above. CSAP1 noted that, *“at the time we had ground*

working sub-contractors and brick-laying sub-contractors. They lost their income on the project for about 2 months; the Christmas period and the period affected by the weather. It had a massive impact on them financially". Therefore, it can be seen that the costs associated with loss of income are transferred down through the supply chain and that sub-contractors specialising in areas such as ground work as particularly affected.

5.1.5.7 Conditions of contract

It was noted by CSA1 that relief for time periods affected by EWEs is available to construction SMEs in most construction projects through the conditions of contract. It was mentioned by CSA1 that *"quirks in construction contracts mean that you will not be penalised for over running if you can prove that you were affected by exceptionally adverse weather conditions. Under the current conditions of contract if you prove, and the onus is on the contractor to prove, that you were affected by exceptionally adverse weather for a particular period, you will be afforded that time but at your own cost"*. However, CSA1 noted that *"a lot of the time it is difficult to prove it really"*, adding that contractors find it difficult to demonstrate whether a particular weather condition was exceptionally adverse.

It was further mentioned that this is also in the interests of the client to grant an extension to a contractor, if the project is affected by EWEs. This was due to the fact the EWEs could affect the quality of the completed construction work. It was stated by CSA1 that *"the way that the contracts are generally set up, is that the client understands your work could be affected to a certain extent by prevailing weather conditions that could be wind, snow and freezing conditions. As I said before if you lay bricks in the rain or in freezing conditions it will affect the quality of the work so it cannot be done. So they are*

not promoting you to progress the work at any cost. There is an understanding thereby that you are allowed extra time". However, CSA further noted that *"the difficulty for contractors is that the costs associated with that prolongation rest with the contractor. Ultimately, it is his risk"*. Therefore, as discussed previously in Section 5.1.3, costs associated with additional time, costs incurred during the disruption period, and loss of income during that period still cause significant impact on construction SMEs, despite the relief available for project duration contractually.

5.1.5.8 Other measures

In addition to the main issues discussed above, several other measures that have been found useful in responding to the EWEs were also cited in the discussions with CSA1 and CSAP1. One of such measures was the existing health and safety procedures. CSA have clearly laid out health and safety standards and procedures that have to be adhered to in carrying out construction work on sites. It was noted that these were found beneficial during the EWEs as these have enabled CSA to make clear decisions on issues such as whether to allow construction work or not and whether to allow workers site access (due to safety concerns). This has also helped CSA to make it clear to employees and sub-contractors that site activities are unable to progress on safety grounds; given that they were concerned about site work being stopped as it affects their income.

5.1.5.9 Synthesis of measures that are in place

It can be seen that following a range of adverse impacts in relation to the EWEs that affected the UK in recent years, CSA has now put in place a diverse range of response measures. Whilst some of these measures were instigated prior to the EWEs (e.g. sub-contracting practices, terms of employment, etc), CSA has developed new measures (e.g.

minimising vulnerable trades during winter, method of construction) in direct response to the EWE impacts experienced. It can be seen that CSA has managed to address most of the impacts experienced, either partially or fully through these measures. Whilst some of the impacts have only been partially addressed, there is the risk that CSA will still experience adverse consequences in the event of a similar EWE. However, Figure 26 demonstrates that to some extent CSA has largely accounted for the majority of impacts experienced.

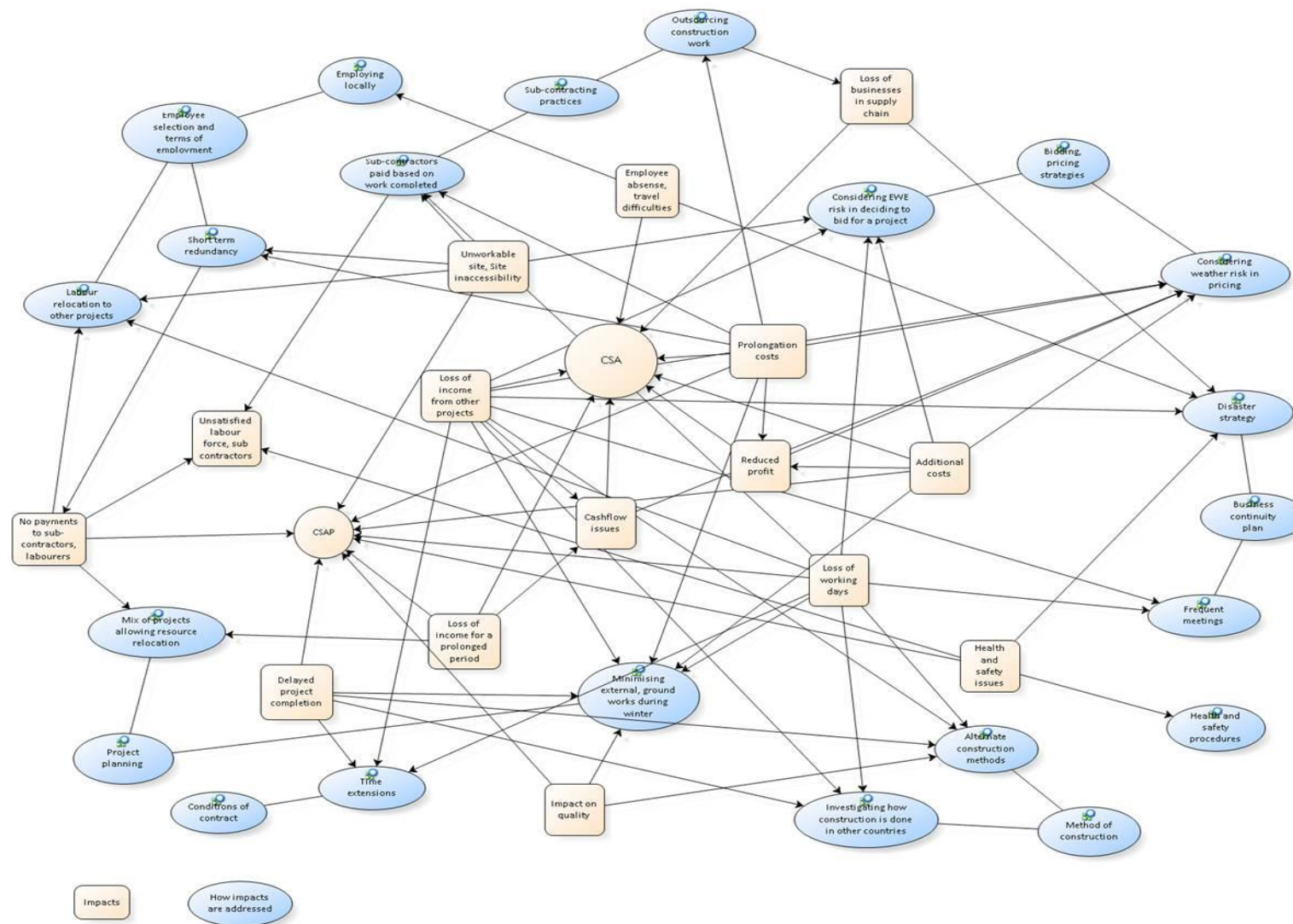


Figure 26 –How EWE impacts have been addressed within CSA

5.1.6 Resilience to EWEs

The impacts of EWEs felt by CSA were elaborated in Section 5.1.3. In the previous section (Section 5.1.5), how the risk of EWEs had been addressed by CSA was detailed. Although CSA has experienced a significant negative impact due to EWEs, CSA considered itself to be adequately resilient to EWEs. Whilst it was acknowledged by CSA1 that CSA is likely to experience negative impacts if a prolonged EWE affects a construction project undertaken by CSA, CSA was viewed as a resilient business that is able to successfully withstand and recover from such impacts. According to CSA1, this is fundamentally due to the risk management strategies that are currently in place and the demographics of the business; including CSA being a well-established business.

As discussed in Section 2.9.2, the resilience of construction SMEs in this study is seen as consisting of their vulnerability, coping strategies and coping capacity within a complex supply chain (external environment). Therefore, the risk management strategies discussed above, in the Section 5.1.5, can be vaguely categorised under measures that reduce vulnerability (e.g. project planning to minimise vulnerable activities during periods vulnerable to EWEs), coping strategies (e.g. relocating employees to other projects) and measures that enhance coping capacity (e.g. conditions of contract). As noted in the Section 2.9.2, these three concepts are thought to be interconnected and overlapping. Therefore, some measures may not fall exclusively under a single category, but may have an effect on two or all the categories.

The extended interview conducted with CSA sought to investigate vulnerability, existing coping strategies and the coping capacity of case study SMEs. Based on the information gathered in this stage, the risk assessment template for CSA and CSB were completed. For

the risk assessment of CSA, please see Appendix - I. A summary of the risk assessment is shown in Table 15.

Accordingly, of the six main business areas considered, site construction activities (production processes), financial situation, and supply chain and logistics were seen as the business areas that have a higher vulnerability profile, lower level of coping strategies and coping capacity; thus a lower level of resilience. Results of the assessment seem to be consistent with the impacts that CSA has experienced in relation to the most recent EWEs. Work on construction sites being disrupted by EWEs and financial impacts that such disruptions have had on CSA were reported as the most significant impacts experienced. This was reflected in the way CSA1 assessed the vulnerability, coping strategies and coping capacity of CSA. Further, supply chain related issues were also identified as a business area with a relatively low level of resilience.

CSA's markets and business premises were seen as business areas with a higher level of resilience. Threat to CSA's markets from EWEs was not seen as high, CSA being a business with a long standing reputation, versatile activity range, and a track record of successful project completions. As discussed previously, the priority for CSA was focussed on its construction projects rather than on business premises. Previous EWE experiences have assured CSA1 that business premises are sufficiently resilient. In regard to business premises, it was noted that it could have been an issue if the premises were in a flood zone. Issues related to CSA's workforce showed that, generally, a medium level of resilience was evident. Whilst travel arrangements of employees was seen as highly vulnerable, other aspects were reported as either low or medium pointing to this area being less of a concern for CSA.

Table 15 - Resilience of CSA to EWEs

Business Area	Vulnerability	Coping strategies	Coping capacity
Markets	Vulnerability of market of the CSA; including demand for its services, reputation, and alternative products from competitors were not seen as high.	Existing coping strategies were seen as largely adequate considering the low vulnerability profile attached to the market situation.	Coping capacity to manage any adverse impact on market related issues were seen as good, primarily due to well established nature of CSA.
Financial situation	Financial aspects of the business were seen as highly vulnerable to EWEs. Vulnerability to loss of income, cash flow issues, and increases in cost of insurance were seen as particularly high (See Figure 24).	Following significant negative financial impacts in relation to EWEs, several coping strategies have been implemented. Therefore, status of coping strategies was seen as medium.	Coping capacity was seen as low. This was influenced by the significant financial hardships experienced and the high vulnerability profile attached to the financial situation.
Supply chain and logistics	Supply chain related issues were generally perceived as highly vulnerable to EWE impacts. Businesses in the supply chain, especially sub-contractors and suppliers were seen as highly vulnerable.	Status of existing coping strategies to manage impacts of EWEs on supply chain related issues were considered as medium to low. This was thus identified as an area that needs improvement.	Similar to coping strategies, coping capacity of CSA to manage impacts on supply chain issues were considered as medium to low.

Business premises	Vulnerability of business premises was seen as low. This is partly due to business premises being allocated a lower significance in relation to EWEs as well as CSA being aware that it is not located in a flood zone geographically; which was thought would have been a concern.	Coping strategies in regard to business premises and access to premises were seen as low. However, due to lower vulnerability level attached implementing coping strategies relevant to business premises was not seen as a critical concern.	Coping capacity of CSA to manage adverse impacts on business premises was seen as high. This was considering the lower vulnerability profile attached to business premises.
Work force	Travel arrangements of workforce were seen as highly vulnerable to EWEs. Other aspects related to workforce, for example health and safety, were seen as medium.	Availability of coping strategies regarding workforce was articulated as medium. This was considering some of the measures that have already been implemented, as discussed in Section 5.1.5.	Coping capacity of CSA on work force was considered medium to high. Having an experienced workforce with a good level of awareness and skills set was seen as a reason behind this.
Production processes and services	Production processes of CSA; activities on construction sites were seen as highly vulnerable to EWEs. This was due to CSA being fully aware of the extent of possible disruptions following recent adverse impacts experienced.	As a number of coping strategies have already been implemented, status of coping strategies was seen as medium. However, it was noted that these might still not be adequate in the event of a future EWE, due to high vulnerability.	Coping capacity of CSA to manage adverse impacts on site work, productivity and cost was seen as low. This is based on the fact that CSA has found a number of sites unworkable for a prolonged period in relation to EWEs experienced.

5.1.7 Measures that could further enhance resilience

In addition to the existing measures discussed above, additional measures that could enhance the resilience of CSA to EWEs were cited in the discussions with the respondents from CSA. These included further expanding some of the measures that are already in place. For instance, it was stated by CSA1 that CSA intends to broaden its investigation into construction practices in countries with wintry weather much of the year; such as Canada. The objective was to learn lessons from construction practices in those countries and explore how those practices can be adapted in the UK.

Whilst the company has already started to consider EWE risk during the winter in its bidding, pricing and project planning as discussed above, CSA1 recognised the need for further improvement in those aspects in order to minimise the negative impacts of a similar EWE in the future. For example, it was cited that whilst the company now undertakes project planning in such a way as to minimise highly vulnerable construction activities during the winter; for e.g. excavating for basements, concrete works, etc, it was identified that there needs to be further improvements in this aspect, especially to get a mix of indoor and outdoor activities on different projects. The reason for this is to allow employee relocation if one project is affected by an EWE for a long period and to ensure that there will be no prolonged periods where the average monthly turnover is not generated.

One of the measures that was identified as having potential was opting for business continuity insurance. Loss of income over an extended period and the financial complications associated with that loss has been a major impact experienced by CSA in relation to the EWEs. As a result, the company is aware of the need for ensuring income

generation throughout the year. Obtaining insurance to cover disruption was, therefore, considered to be a possible remedy. In regard to business interruption insurance; it was stated by CSA1 that *“it is something that we need to look at in the future. To be honest we have not looked at the policies in depth. So, certainly we have to see what the insurance providers’ view is”*. However, it was also mentioned that the cost of obtaining such an insurance policy is likely to be extremely high.

5.1.8 Reasons preventing further measures being implemented

Discussions with the respondents from CSA shed light on the reasons that prevent them from implementing further measures or expanding existing measures to address the risk of EWEs.

CSAP1 considered EWEs to be an unavoidable risk in the construction industry. It was mentioned by CSAP1 that, *“it depends on what the situation is; we know there really is not going to be flooding here for instance. I would not say there are any contingency plans for the weather we have had, because it is difficult to plan for it, because even if you do plan for it, it is still going to affect you. So the contingency plan is to do the best you can”*. A similar viewpoint was echoed by CSA1 that *“I think that as we are working on sites, if the weather stops you from doing that there is only a little that you can do. But planning early is very important”*. However, as opposed to CSAP1, CSA1 affirmed that early planning can lead to enhanced resilience.

The high cost of possible measures was also seen as a barrier to their implementation. For instance, it was noted by CSA1 that it could have been possible to carry out construction activities amidst EWEs on some of the sites, if interventions were made to reinstate

suitable working conditions. However, it was stated that these would have been extremely expensive; *“looking at counter measures, providing different temporary heating methods or shelters, they are massively expensive to implement”*. Therefore, the cost of such measures was considered to outweigh the benefits. Similar concerns about higher cost were made in relation to other resilience measures; for example business continuity insurance.

5.1.9 Information / support requirements

CSA1 highlighted that there is a dearth of information available for construction SMEs on how to respond to EWE risk. This lack of information was linked to a lack of preparedness and thereby construction SMEs experience significant negative impacts. CSA1 cited that *“I think more information certainly would be beneficial. I think there is very little information about how to combat or deal with these situations, and that is not necessarily just for SMEs, nationally. It is a kind of a new phenomenon I think really, that construction companies do not know how to deal with them”*. Further, it was stated by CSA1 that *“that advice leads to best practice where you react quicker, reducing the risk certainly”*. Therefore, making practical, applicable information available for construction SMEs was recognised as one of the primary requirement with regard to EWEs.

It was mentioned by CSA1 that the uncertainty associated with EWE risk was a concern for construction SMEs, as being over cautious could result in less construction activity for an SME. It was stated by CSA1 that *“one thing that we could do is to relocate, redistributing work force to jobs that are not affected by the weather. So if we can get assertive weather warnings in advance it will certainly help”*. Another issue highlighted therein is the need for receiving EWE warnings well in advance, so that the company is in

a position to respond to the situation better; for example by planning to relocate the workforce to other projects in areas not at risk of a particular EWE.

Issues associated with the transport network were also cited by CSA1 and CSAP1. CSA1 said that *“one of the problems for our employees was transport and access during the severe weather period. So if the local councils can do their bit to ensure that people have got access via public transport and making sure that the road network is operative I think is a big part of it”*. Disruptions to transport networks was a commonly experienced phenomenon throughout the UK, in relation to the EWEs that have had a significant impact on CSA (BBC News, 2009; 2010b).

5.1.10 Summary of case study 1

As observed in the qualitative analysis of data gathered from the respondents of CSA, the company has experienced significant adversities due to EWEs during the couple of years before the case study was conducted. This has resulted in the company considering EWEs to be a critical risk to its business activities, and the risk being reflected in decision making both operationally and strategically.

Analysis of existing coping strategies of CSA revealed that the company has a number of strategies in place for managing the risk of EWEs in their construction projects. Whilst most of these strategies have traditionally focused on adverse weather, the company is increasing considering the risk of EWEs in planning and executing construction projects. Further, it was noted that some of the general risk management strategies that are in place within CSA; such as business continuity planning, terms of employment, and sub-contracting practices, have contributed to their resilience to EWEs. CSA has identified that

several decisions that were implemented with commercial advantages in mind (e.g. change of terms of employment to allow CSA to temporarily lay off employees), have led to reduced impact to their business from the recent EWEs. This approach is similar to that identified by Berkhout et al (2004) who noted similar instances where commercial decisions have led to improved organisational resilience.

The effectiveness of existing strategies and the need for new strategies; i.e. strategies that CSA has considered following the recent EWEs, have been assessed in relation to the EWE impacts experienced by CSA. Therefore, the strategies that have been developed are in response to the impacts experienced, rather than to EWEs in general or based on an objective assessment of future EWE risk. These findings are in line with what previous research has reported; i.e. that response to EWEs is likely to be based on previous EWE experiences.

It was noted that the damages related to EWEs; especially in relation to loss of income and thus the financial impacts of such events, cascade down the supply chains. This seems to have resulted in significant hardship to construction SMEs who specialised in trades sensitive to weather. Whilst the current level of resilience backed by the sound financial position of the company has enabled it to absorb the damages caused by EWEs and plan for the future, this might not be the same for construction SMEs of less stature. This explains why construction SMEs were found to be the business sector most adversely affected by EWEs in some of the previous studies.

In order to shed further light on the research questions being investigated, a second case study was conducted. The second case was purposively selected as discussed in Section

3.7.1.2, to represent a trade identified by CSA as significantly affected by EWEs, a sub-contracting SME specialising in earthworks and civil engineering construction. The next section introduces the second case study organisation, case study informants and discusses the findings of the semi-structured and extended interviews.

5.2 Case study 2

As discussed in the Section 3.5.4, the study was developed as a multiple case study. Following the interviews with resource persons from the case study organisation 1 (CSA), interviews were conducted with the resource persons from the second case study organisation; CSB. Findings of the interviews conducted with the respondents from B are described in the following sub sections.

5.2.1 Background to the organisation

The second case study SME (CSB) is a privately owned medium-sized construction company with about 220 employees. CSB has been in business for over 60 years and therefore is a construction organisation with a sound track record. CSB is primarily a civil engineering company involved in land remediation and earthworks, demolition and ground works, highways and bridges, and river and coastal engineering. CSB is based in the North West of England and whilst on the larger complex projects it operates nationally, a high proportion of its construction projects are in Wales, Northern England and the West Midlands.

The management structure of CSB is noticeably different from that of CSA, largely due to the size of the business and thus the volume of business activities. As it was discussed in the Section 2.4.2, medium-sized enterprises with over 200 employees are likely to have a

much different management structure to that of small businesses or medium enterprises with an employee base closer to the lower limit of 50. CSA's management structure was much closer to that of a small business although it is a medium-sized business. This difference in size between the two case study SMEs is desirable to obtain the perspectives of construction SMEs representing the lower and upper limits of SMEs.

As the primary area of operation for CSB is civil engineering as opposed to building construction it was thought that CSB would provide a different perspective to that of CSA. It was envisaged that this would provide a good account of the construction SMEs operating in both building and civil engineering works whilst allowing useful comparisons to be made between the two sectors.

5.2.1.1 Case study informants (organisational)

Whilst a single informant was interviewed in the case of CSA, due to its management structure and decision making within the organisation, three informants were interviewed from CSB. This was to obtain a comprehensive account of issues being investigated from an organisation which is much larger in size than CSA, and has a tall organisation structure with a more complex management hierarchy (See Appendix-M for the organisational structure of CSB). Although the semi-structured interviews were conducted separately, extended structured interviews for completing the risk assessment template were conducted as a group interview, as pointed out in the Section 3.7.1.3 under the research methodology adopted in the study. Accordingly, a director (CSB1) in charge of contracts and two senior commercial managers (CSB2 and CSB3) were interviewed. All the personnel interviewed are experienced construction professionals who have been with CSB for a long period. Therefore, they were able to recount an

informed and broad account of CSB in relation to EWEs; and provide rich qualitative data for the study.

5.2.1.2 Selected construction project

Similar to the first case study, a project undertaken by CSB was selected for investigation, in consultation with the senior management interviewed at organisational level. The project selected for this purpose (CSBP) was a land remediation and drainage project in which CSB was a specialist sub-contractor involved with land remediation work. The total project consisted of remediating land contaminated with a chemical by-product to limit further damage to the environment and reinstate the land for future use, and had a total project cost of over £3million. The site manager responsible for the delivery of the project on behalf of CSB (CSBP1) was selected to gather information using the semi-structured interview template designed for construction site management staff. CSBP1 was an experienced site-manager who has managed a number of civil engineering projects undertaken by CSB.

5.2.2 Previous experience of EWEs

CSB was said to have been affected by heavy snowfall, heavy rainfall, flooding, and extreme temperatures; both high and low, during the recent past. It was stated by CSB1 that *“yes, definitely, some of our projects were affected. It became a significant issue on a number of projects”*. It was noted that one of the road construction projects of CSB was flooded a few months before the interview was conducted. Being largely a civil engineering company where a majority of construction activities happen in the open environment, it was noted that extreme temperatures; low temperatures as well as high temperatures and heat waves, have also adversely affected the activities of CSB.

Therefore, CSB was mindful of EWEs that reduce productivity and entail additional costs to its projects, although the work continued to progress and was not completely suspended. Such EWEs were also mentioned as important, given the impact that they have on project programmes and finances, despite the work is not being suspended for a long period of time. This is somewhat different from the perspective of CSA, where the focus was mainly on EWEs that suspend project activities over a prolonged period of time.

The project selected from CSB; CSBP, has been affected by heavy snowfall at the same time as CSAP. As a result, activities on the project were suspended for about two weeks during the heavy snowfall. Being a land remediation project, CSB was not able to access the site of CSBP during this period due to snow covering the site. It was stated by CSBP1 that *“the site was completely covered with snow. So we could not get any work done for about 2 weeks”*. The hazardous nature of the site following the heavy snowfall prevented CSB from carrying out site activities during that time.

5.2.3 Impacts of EWEs

5.2.3.1 Impacts on CSB

CSB has experienced a range of impacts in relation to the EWEs that have affected its activities. Similar to the case of CSA, the financial impact of loss of income and additional costs was highlighted as a major impact due to EWEs. CSB has experienced loss of income on a number of projects due to EWEs. For example, it was stated by CSB1 that *“one of our projects was severely affected by snow on the ground; there was 6-7 inches of snow on the ground. And we could not compact the earth, because there was water. And it was a fixed price lump sum project. So the risk was entirely ours”*. Being a specialist sub-

contractor, it was noted that the payment method was the fixed price lump sum method; where the contractor is paid a fixed sum for the project, this was the case in a number of projects that the CSB has undertaken. This has led to CSB being unable to recover the additional costs incurred during periods of EWE disruption.

The standard practice of CSB was not to sub-contract any work but to implement all projects using in-house resources. CSB is a diverse SME, in which all the resources are available; including plant, machinery and labour, to undertake projects in which it specialises. This however has led to CSB having to absorb the complete financial impact of EWE disruption, as it was not in a position to transfer the risk down the supply chain. It was mentioned by CSB3 that *“we do the vast majority of the work which we do ourselves, and we do not sub-contract work. We do all the demolitions ourselves, the earthworks, plant and equipment supply. It is mainly all in-house. So when the work is disrupted it is quite costly for us”*. Therefore, unlike in the case of CSA, CSB has not been able to transfer some of the costs associated with the EWE disruptions to its supply chain partners, including sub-contractors.

From experience of a project affected by EWEs, it was noted by CSB2 that the need to accelerate following EWE disruption can lead to further costs for construction SMEs. It was stated that *“we tried to reduce the impact on the project and to get it back on programme. We tried to accelerate but there was some inefficiency with that as well– for instance we doubled the resources to recover the two weeks that we lost because of weather, and after that it rained for a couple of days so we had double the resources standing. So the costs were considerable for; first standing and second in trying and recover it”*. Several examples were mentioned where subsequent EWE disruptions have

led to higher costs and resources wastage, due to sites being further affected when additional resources have been allocated to accelerate work and recover from previous EWE disruptions.

In addition to these impacts, the health and safety risk associated with EWEs for site staff was also highlighted. It was noted that CSB was not in a position to re-start site activities on some sites due to health and safety concerns following the heavy snowfall. Further, it was noted that CSB had to introduce additional controls on sites, including additional breaks for site staff and additional environmental control measures (e.g. dust control) in relation to high temperatures associated with heatwaves in the summer. High temperatures were identified as particularly damaging for productivity on sites, due to difficult working conditions for site staff.

5.2.3.2 Impacts on CSBP

In CSBP, CSB has suffered a significant financial loss as a consequence of restricted site operations for about two weeks due to heavy snowfall. Being a specialist subcontractor, CSB supplied all the plant, machinery, materials and labour in CSBP as mentioned above. As such, CSB has had to absorb the full impact of the disruption. Similarly, all labour being directly employed, CSB were required to pay wages for the duration of the disruption, unlike in the case of CSAP.

Whilst the project activities were completely suspended for about two weeks, it was noted that the loss of productivity lasted for longer than this initial period of disruption. According to CSBP1, this was due to ground conditions not being favourable for earthworks for the weeks following the initial disruption. This had a negative impact on

the project programme as the activities did not progress as planned. As a result, CSB were required to accelerate the site activities by allocating further resources, as the company's policy was to meet the project completion dates as often as possible. Accelerating project activities has led to additional costs for CSB than had been planned at the time of bidding.

However, CSB was hopeful that some of the costs associated with the disruption could be recovered. It was stated by CSB3 that *"it is on NEC form of contract and we are looking to get back the money while we were standing whilst snow was on the ground, I am working on the claim now"*. It was noted that since the project was based on an NEC form of contract, CSB would be able to recover costs associated with the heavy snowfall. Relief may not be available in other forms of contract; as stated by CSB3 *"but I think on some of the other forms of contract you do not necessarily have the opportunity to get money back. The risk will often lie with us. You need to be right or wrong when you are pricing"*.

5.2.3.3 Synthesis of EWE impacts

Similar to the case of CSA, CSB has suffered a range of impacts due to EWEs. These have ranged from direct financial impacts to health and safety concerns for employees and spiralling costs associated with accelerations, demonstrating the broad range of impacts associated with EWEs (see Figure 27). Figure 27 demonstrates how the impacts on CSBP and on the other projects have affected CSB, as discussed in Sections 5.2.3.1 and 5.2.3.2.

Information provided by all the respondents from CSB confirmed the supposition that construction SMEs specialising in some of the trades were particularly vulnerable to EWE disruptions and that they are affected disproportionately hard. Further, CSB has been required to absorb the costs of EWE disruptions within the company, as the company

does not sub-contract any work on its projects. Comparatively, CSA was in a position to transfer some of the costs associated with EWE disruptions to its sub-contractors and employees. This suggests that sub-contracting practices seem to act favourably for construction SMEs when the project activities are disrupted for a prolonged period of time. In addition, unlike the case of CSA, CSB was not in a position to temporarily lay-off some of its site staff during periods of disruption where there is a surplus of labour; i.e. when site works are suspended. Therefore, CSB has been required to make payments to its site staff during the periods when site activities had to be suspended due to EWEs as they are directly employed by CSB.

Whilst CSA was unable to recover additional and prolongation costs associated with prolonged EWE disruptions, CSB was hopeful that some financial recovery existed under an NEC form of contract. This relief, through conditions of contract, was available in addition to time extensions that were allowed to compensate for the time lost due to EWE disruptions. This emphasises the importance of conditions of contract in recovering time and costs associated with EWE disruptions. The NEC form of contract may be advantageous in the future for construction SMEs, given the anticipated increase in intensity and frequency of EWEs in the UK.

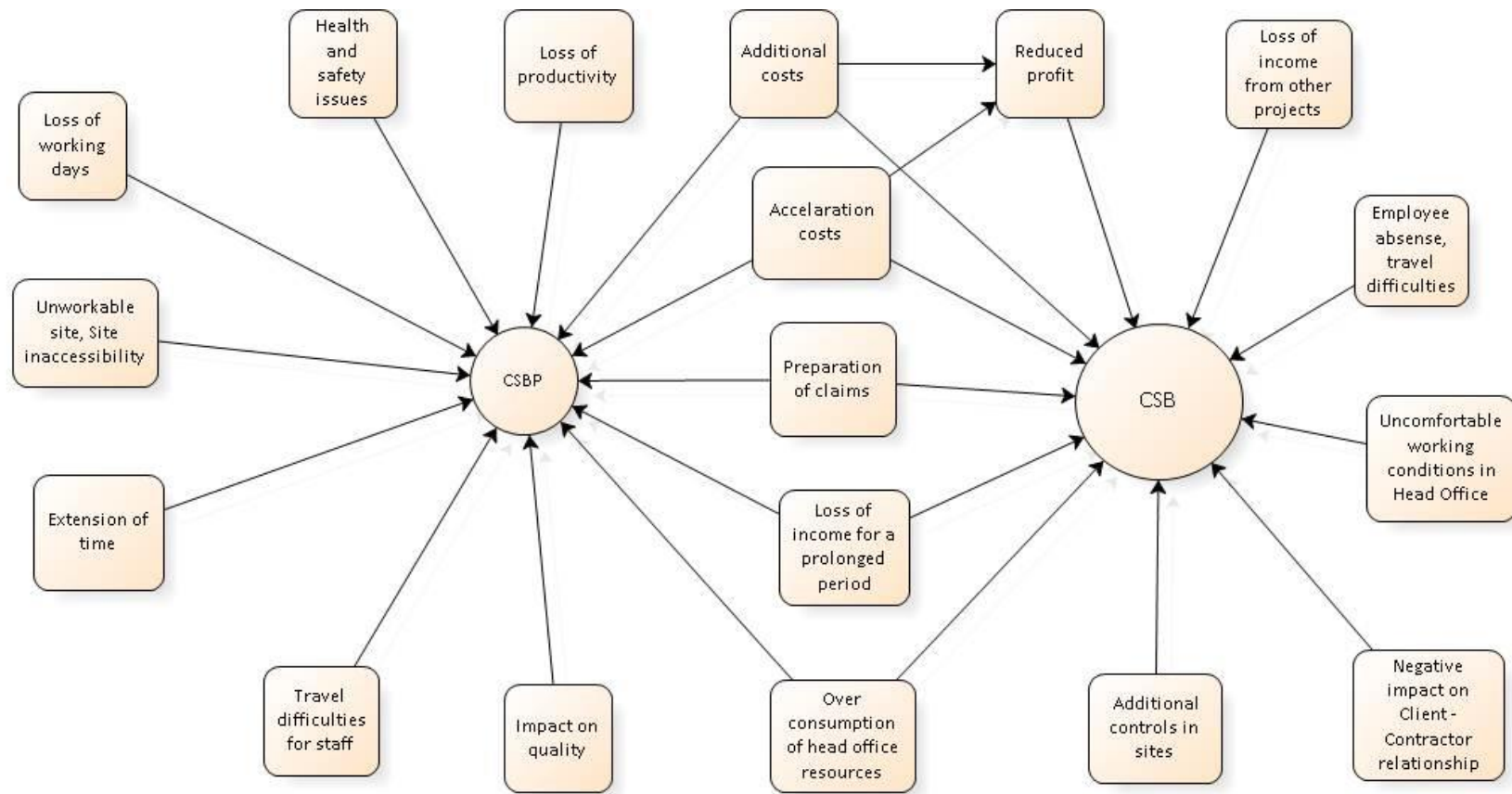


Figure 27 - Impacts of EWEs on CSB and CSBP

5.2.4 EWEs as a critical business risk

Respondents from CSB viewed EWEs as a critical risk to its business activities. This is contradictory to the questionnaire survey findings, where EWEs were not considered to be a significant risk (see Section 4.7). However, as both the case study SMEs have experienced significant impacts associated with EWEs during recent years, they were much more sensitive to the risk posed by EWEs. Therefore, the findings from the case study research affirm that EWEs are a significant risk to construction SMEs, where the impacts can be overwhelming to a business. Confirming this, it was mentioned by CSB1 that *“extreme weather events are devastating in terms of programme and cost, it is quite catastrophic”*.

Accordingly, similar to the views expressed by respondents from CSA, significant detrimental impacts to site activities and the resulting financial impacts associated with EWEs; including loss of income and additional costs, were identified as the most significant impacts of EWEs. The fact that construction SMEs operate on tight profit margins, under difficult economic conditions, was emphasised as an additional factor in the significance of EWE disruptions. This means that a loss of income for even a short time period was capable of having a significant financial impact on a construction SME.

EWEs were identified as particularly damaging for construction SMEs undertaking fixed-price lump sum projects and projects in which provisions are not made in the conditions of contract to reimburse the costs associated with EWE disruptions. A broad range of other impacts such as those to the workforce and supply chain were identified as contributing to EWEs being a critical risk to construction SMEs (See Figure 28). For instance, it was mentioned by CSB1 that EWEs could contribute towards the adversarial

nature of client – contractor relationship within the industry. It was mentioned that some clients are less comprehending of the difficulties faced by construction SMEs due to EWEs, whilst the attempts made by a contractor to accelerate the activities following a EWE disruption can affect the client – contractor relationship negatively. The importance of client – contractor relationships based more upon cooperation and trust have been emphasised as essential to achieve better performance and value in construction (Latham, 1994; Bresnen and Marshall, 2000; Wolstenholme, 2009). The claim made by CSB1 is that EWE situations can have a negative impact on the relationship with clients as they could lead to disagreements and disputes. It was stated by CSB1 that *“it is catastrophic because the morale dips. We have got people out there with lots and lots of skills trying to recover that situation – without those skills you will not get anywhere near it. The client thinks that that is your fault, it is frustrating for the client when he thinks it is your fault. But it is the weather and we are trying everything to recover the programme. So when that happens morale dips and it affects people on the site as well”*. Whilst accepting that it is the responsibility of construction SMEs to perform as agreed, the need for clients to be sensitive to the problem of EWE disruptions amidst the increase of such events during the recent years was emphasised therein.

5.2.5 Existing risk management strategies against EWEs

How the risk of EWEs is currently addressed within CSB was investigated as part of the semi-structured and extended interviews conducted with respondents from CSB. Accordingly, a number of initiatives were discussed, including measures specifically focusing on EWEs as well as general risk management strategies which were thought to contribute to EWE risk management within the CSB.

5.2.5.1 Estimating and bidding strategies

Considering the risk when quoting for a project was highlighted as one of the main ways of addressing the risk presented by EWEs. It was stated by CSB2 that *“we add in time and money for weather. That is what we do in our estimating process. And obviously we learn from different situations and reflect that back when pricing other works”*. It was the view of CSB1 that it is critical to *“identify them early, price them early”*, if the risk of EWEs is to be adequately addressed in its projects. Further, as is quoted in the above statement from CSB2, it was noted that the company learns from previous experiences; projects that have been affected by different EWEs, and the lessons learned are considered when pricing future works.

Furthermore, it was stated by CSB3 that *“we take in to account the type of work, time of the year that we are going to be working because of the affects of the weather as well as whom you are going to work for. Because if you are going to work with a client who understands your risk, it has to be taken in to account. If he does not, then there will be conflict, so we have to consider that when pricing the work”*. It was mentioned that some clients understand EWE situations whilst some do not. Therefore, following a number of their projects being affected by EWEs, and as these have sometimes negatively affected

their relationship with clients, the company has now started to consider who the client is and factor that in when bidding for a project.

5.2.5.2 Diversity of business activities

Having a diverse range of business activities within CSB was highlighted as a counter measure against EWE disruptions. It was stated by CSB1 that *“diversity of work, I think that is what we have been doing and we will continue to get better at. I think that is our game plan”*. Similar viewpoints were expressed by the other respondents from CSB, where it was stated by CSB2 that *“I think the fact that we are a diverse business, I think we are fortunate we have quite a spread of work at the moment and might do a bit more of that in the future”*, whereas it was stated by CS3 that *“we have now, and we need to keep it up; it is not easy, but that is where we need to be, I think we are reasonably resilient because we have got a good spread”*. Diversity of work was also identified as a factor contributing towards CSB being a resilient business against EWE disruptions, and being in a position to absorb the impacts of EWE disruptions in some of its projects.

It was noted that if the company had restricted its work only to its core activities; earthworks and remediation, it would not be such resilient organisation as it is now. Several examples of construction SMEs restricted to earthworks and remediation were cited which, according to CSB1, are in a difficult situation following the EWE disruptions. It was stated by CSB1 that *“I think with respect to this they are struggling. And I think a lot of it is due to the type of work they are doing and the type of conditions, I mean in bad winters, they are affected”*.

5.2.5.3 Frequent meetings

Frequent meetings held on sites and in CSB's head office were identified as a risk management strategy, where any issues at the time are discussed and actions to be taken are planned. It was cited that it is the company's policy to have site meetings fortnightly and management meetings at the head office monthly. It was stated by CSB1 that *"I think we have not got a contingency plan as a standard policy, and I think the reason for that is that every situation is quite unique. What we do have is, we have team meetings on site fortnightly and we have management meetings once a month"*. Management meetings were said to be attended by the senior management based at the head office. It was mentioned that site management staff are also called for management meetings, if any significant issues pertinent to a particular site are scheduled to be discussed at a management meeting. This was confirmed by CSBP1, where it was stated that *"we normally have site meetings once every two weeks. I sometimes get called for management meetings held at the head office. We have a lot more than that when something goes wrong"*.

The comment from CSB1 quoted above also highlights why the company has not got a formal business continuity plan (see Section 2.5.3.2) in place. Every situation was considered as unique, requiring a specific response appropriate to that situation. Therefore, arriving at an appropriate response following discussions between site staff and management staff at head office was stated as company policy, rather than having a standard contingency plan as discussed in Section 2.5.3.2. However, it was noted that this approach consumes head office expertise to a considerable extent when a disruption

occurs, and limits the time available for other activities; thus having a negative impact on the day to day management activities of CSB.

5.2.5.4 Conditions of contract

Conditions of contract were highlighted as one of the most prominent relief measures available for construction SMEs. As discussed in Section 5.2.3.2, CSB was in the process of preparing a claim for an additional payment on CSBP, for the period when site activities were suspended due to heavy snowfall. This has been made possible due to the fact that the NEC form of contract recognises EWEs as a compensation event, when the contractor may be entitled to additional payment (NEC, 2005). However, it was noted that this relief is not available on projects executed under some of the other standard forms of contract. CSB2 stated *“but I think on some of the other forms of contract you do not necessarily have the opportunity to get back. The risk will often lie with us. You need to be right or wrong when you are pricing it”*.

Similarly, it was noted by CS3 that *“NEC contract has got something in there, but the building contracts have got nothing at all. In other contracts you only get extra time, but not the costs”*. This is in line with findings from CSA, where it was found that CSA was not been able to recover costs associated with EWE disruptions (see Section 5.1.5.7). CSA was only able to request an extension to complete the project, but not the costs associated with the disruption. However, it was noted that proving that a particular weather condition was an EWE is a challenging task for construction SMEs, especially given the increase in such events; for example heavy snowfall, low temperatures and heavy rainfall, during the recent years. This aspect will be further discussed in Section 5.2.9.

5.2.5.5 Project planning

Similar to the viewpoint expressed by the respondents from CSA, the importance of proper project planning was emphasised by both the senior management and the site management of CSB. Accordingly, it was stated that every effort is now being taken to minimise vulnerable work activities during winter months, especially December and January, given the significant disruptions experienced in the previous two years. Citing the example of a project that CSB has been awarded and was planning to commence at the time the interview was conducted, it was stated by CSB1 that *“we have identified works which are non-critical; we will leave those to that time of the year. So a lot of planning has gone into it, rather than get on the site in January do the earthworks, we have slipped the programme and we should be doing it in March and April really”*. As mentioned by CSB1, the programme of projects has been planned in such a way as to avoid earthworks being conducted in January, as CSB has seen how heavy snowfall negatively affected earthworks during January of 2009 and 2010.

However, a caveat for this was also discussed; wet summers that the UK has experienced during recent years. It was discussed by the respondents from CSB that it is the usual practice of construction companies to plan the work in a manner that utilises good weather in summer to compensate for the loss of productivity during the winter. However, it was noted that construction SMEs were not in a position to capitalise on favourable summer weather, as recent summers have been characterised by heavy rainfall, thus disrupting construction work on a regular basis. It was stated by CSB3 that *“what you have got to do in the summer is to get everything out earning and doing more work, say from 7 till 7. And then you store a little bit of cash. And then in the winter it is a*

way out of it and hopefully you will still be in a positive position. But I do not think that has happened in the last five years. I do not think we have had a good summer in the last five years". This comment was not without basis, as the records show that the UK has experienced a number of wet summers during the recent past (Sutton, 2012; Environment Agency, 2013). Therefore, it was suggested that this has adversely affected the construction SMEs during recent years.

5.2.5.6 Other measures

In addition to the measures discussed above, several other measures were also discussed. One of such measures is employing experienced and qualified professional staff across every section of CSB. This has enabled CSB to make better decisions with regard to EWE impacts and the counter measures discussed above. In particular, possession of in-house expertise was identified as a key enabler for preparing and submitting claims to recover costs as well as time extensions following EWE disruptions. Lack of such expertise was stated as an issue that may affect some of the smaller construction SMEs.

Further, in terms of workforce, CSB's policy was to employ locally as much as possible. This has minimised the distance that employees are required to travel to reach their workplace; head office and project sites. In a similar approach to that of CSA, CSB respondents mentioned that every effort is taken to allocate site staff to sites that are in close proximity to where they live. This was noted as a measure that has minimised EWEs adversely affecting staff travelling to and from their workplace.

Acceleration was mentioned as a measure that is widely used within CSB to recover following EWE disruptions. As discussed in Section 5.2.4, the policy of CSB was to

endeavour to recover the programme as much as is feasible following any disruption. Therefore, this was noted as a counter measure used to minimise adverse impacts on the project programme following an EWE disruption.

5.2.5.7 Synthesis of how the EWE risk is currently addressed

Analysis of the ways and means of how the risk of EWEs is currently addressed by CSB reveals that CSB has addressed the risk of EWEs via a number of strategies. It was claimed by CSB1 that CSB has addressed most of the areas susceptible to being affected by EWEs to some extent; *“I think we have covered most of the areas to some extent. We have covered estimating, the stuff we do on sites we have covered, contractual management of that risk we have covered”*. Figure 29 depicts how CSB has addressed the impacts experienced in relation to previous EWEs. Confirming the statement by CSB1, it can be seen that the current risk management strategies in place address much of the EWE impacts that CSB has experienced during the recent past.

Whilst some of those strategies were already in place as part of the general risk management strategies and commercial strategies within CSB (e.g. diversification, estimating practices), some of the strategies discussed specifically focus on EWEs (e.g. NEC conditions of contract). In the main, it can be noted that most of these strategies were common to both construction SMEs. Use of NEC conditions of contract, where construction SMEs are provided respite for EWE disruptions in terms of costs and additions to time, was a strategy that was not discussed in relation to CSA. As noted by CSB1, this is due to the limited adoption of NEC on building projects, and therefore, construction SMEs who specialised in building trades were noted as unlikely to recover costs associated with EWE disruptions. The relief available in the NEC conditions of

contract can be considered significant, given the significance associated with financial impacts of EWE disruptions. For example, respondents from both case study construction SMEs considered the financial impacts of loss of income and additional costs to be critical risks.

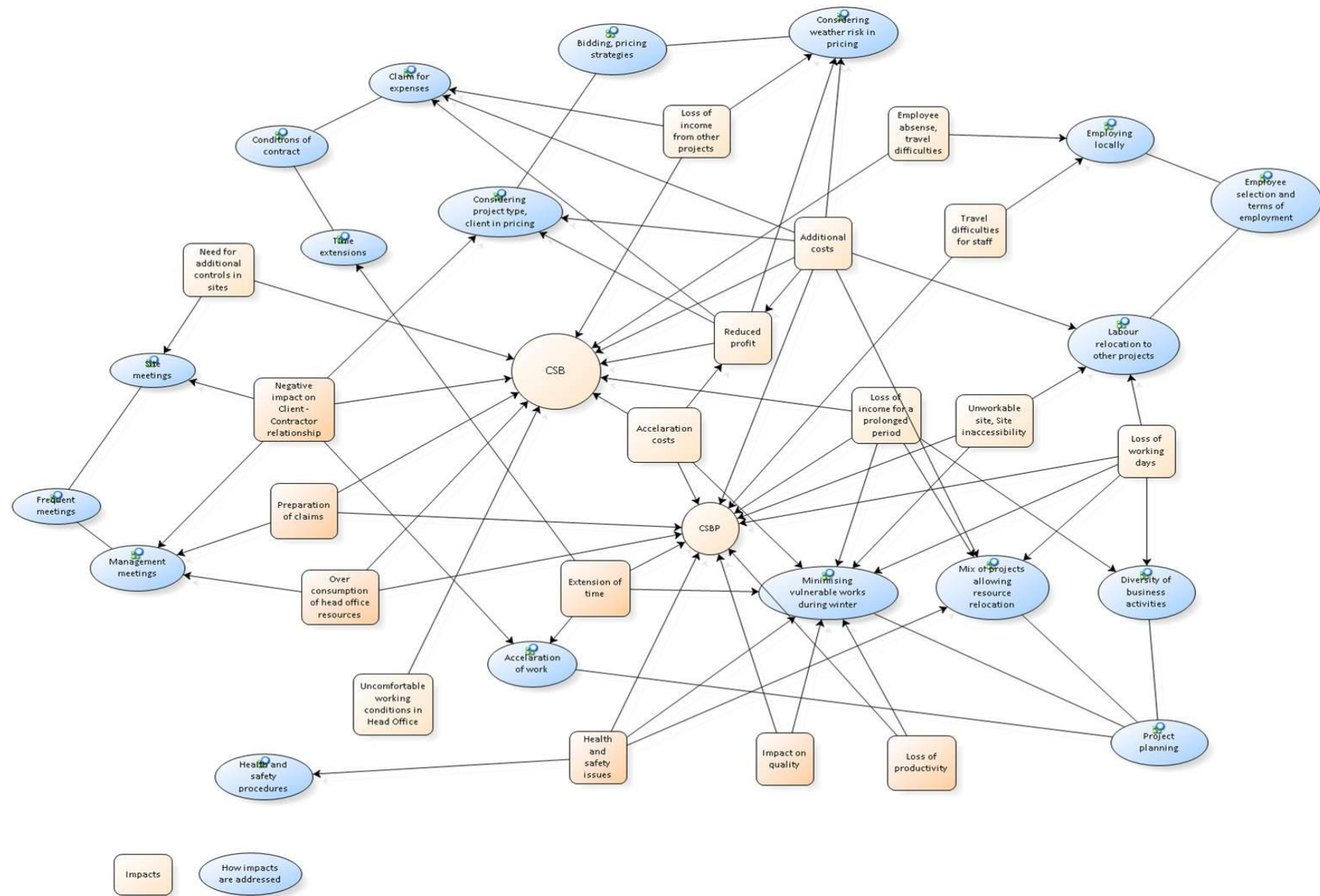


Figure 29 – How EWE impacts have been addressed within CSB

5.2.6 Resilience to EWEs

As in the case of CSA, the risk assessment template developed for the study was completed for CSB following the extended interview with the respondents from CSB. The completed risk assessment template for CSB can be seen in Appendix – J. A summarised version of the risk assessment is shown in Table 16; it shows that the respondents viewed CSB to be a business resilient to EWEs. Site activities and the impact on financial aspects were deemed to be areas with relatively high risk profiles. However, given that the risk is currently being addressed (see Section 5.2.5), and taking into account other issues that contributed to CSB’s resilience, overall the organisational resilience was considered high.

In terms of market situation, CSB was seen to be largely resilient. This is due to factors such as CSB operating a diverse business organisation with an extensive portfolio of projects, a strong financial position, well-established reputation and business image and a competitive business organisation with a strong resource base. As in the case of CSA, the results from the assessment of CSB were consistent with the impacts that have been experienced in relation to recent EWEs. This has reflected in the way the respondents from CSB assessed the vulnerability, coping strategies and coping capacity of CSB. Whilst financial aspects such as turnover and insurance were allocated a lower resilience profile, aspects such as investment and liabilities were allocated a high resilience profile. This is due to the impact of the EWEs experienced by CSB (see Section 5.2.3), how the risk has been addressed (see Section 5.2.5) and the strong financial position of the company.

Supply chain related issues were not allocated a low resilience profile due to CSB operating on an “in-house” basis. However, logistics related issues were allocated a low resilience profile, again based on the experience of adverse impacts and potential risk of

disruption. Whilst the business premises were noted as being rather uncomfortable during the summer when the temperatures are high, this was not considered a major issue. Accessibility was seen as a problematic issue in relation to heavy snowfall, such as CSB has experienced recently. Issues related to the workforce of CSB were generally thought to have high level of resilience, apart from staff travel arrangements which were considered vulnerable due to transport infrastructure being affected by EWEs. However, coping strategies such as employing locally contributed to the resilience of this aspect. The skilled, experienced workforce of CSB was seen to be one of its major assets. Site activities were allocated a high vulnerability profile in almost every aspect considered in the assessment. This is due to the significant impact of EWEs that CSB experienced on its projects in the recent past. It was noted that a range of coping strategies have been implemented to address the risk to site activities and coping capacity was seen to be medium.

Table 16 – Resilience of CSB to EWEs

Business Area	Vulnerability	Coping strategies	Coping capacity
Markets	Vulnerability of different aspects related to market situation was not seen as high. Given the possible impact on client – contractor relationship vulnerability of business reputation was seen as medium.	The company has implemented a number of coping strategies that contributes to its market situation (see Section 5.2.5). Diversification and the current portfolio of a good spread of projects were seen as significant issues.	Coping capacity to manage any adverse impacts on market related issues were seen as good, due to CSB being a well-established business with a good track record, financial profile and product range.
Financial situation	Financial aspects of income generation and insurance were seen as highly vulnerable. Ability to attract investment and complying with statutory financial provisions were not seen as vulnerable, due to strong financial position of CSB.	Following significant negative financial impacts in relation to EWEs, several coping strategies have been implemented (See Section 5.2.5). However, it was identified that more can be done. Therefore, status of coping strategies was seen as medium.	Coping capacity in terms of income generation was seen as low. This was due to high possibility of site activities being disrupted in the event of a EWE. Coping capacity of other financial aspects were seen as medium.
Supply chain and logistics	Transport and delivery systems and material supply was seen as highly vulnerable, due to vulnerability of transport infrastructure. As	Status of existing coping strategies to manage impacts of EWEs on supply chain related issues were considered as medium	However, coping capacity was identified as medium to high. This is due to factors like excellent network of supply chain that CSB

	the company normally does not sub-contract work (see Section 5.1.3.3), other aspects were not seen as highly vulnerable.	to low. This was thus identified as an area that needs improvement.	has established over a period of time, thus enabling it to quickly source from different suppliers.
Business premises	Vulnerability of business premises was seen as medium to low. This is partly due to business premises being allocated a lower significance in relation to EWEs. However, internal working environment in relation to high temperatures was seen as vulnerable (see Section 5.2.3.1).	Coping strategies in regard to internal working conditions and access to premises were seen as low. Therefore, these two aspects were seen as areas that need improvement, to avoid loss of productivity and inconvenience to employees.	Coping capacity of CSB to manage adverse impacts on business premises was seen as high. This was considering the lower vulnerability profile attached to business premises and the issues not being critical to its survival.
Work force	Travel arrangements of workforce were seen as highly vulnerable to EWEs. Other aspects related to workforce were not allocated a high vulnerability. This is partly due to workforce being paid, even if the work is disrupted.	Availability of coping strategies regarding workforce was articulated as medium. For example, it was noted that well established procedures exist in relation to health and safety issues.	Coping capacity of CSB on work force was considered medium to high. Having an experienced workforce with a good level of awareness and skill set was seen as a reason behind this, as in the case of CSA.
Production processes and	Site activities of CSB were seen as highly vulnerable to EWEs. This was due to CSB	As a number of coping strategies have already been implemented, status of	Coping capacity of CSB to manage adverse impacts on site work was seen as low.

services	having experienced significant impacts on all aspects related to sites in relation to recent EWE disruptions. Reducing vulnerability on site was therefore identified as a key issue.	<p> coping strategies was seen as medium. </p> <p> However, it was noted that these might still not be adequate in the event of a future EWE, due to high vulnerability. </p>	<p> Coping capacity of other aspects including cost were seen as medium. For instance, this is due to the ability to recover costs under conditions of contract (see Section 5.2.5.4). </p>
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5.2.7 Measures that could further enhance resilience

Considering how the risk of EWEs has been addressed within CSB, the respondents were of the opinion that CSB is sufficiently resilient to EWEs and is in a capable position to manage the potential adverse impacts of EWEs, as discussed in the previous sub-section (Section 5.2.6). One of the strategies that were thought to be appropriate for implementation in the future was that of sharing the risk with the client. It was noted that this approach has already been implemented in a project undertaken by CSB, in which the flood risk was undertaken by the client. In relation to the said project, it was stated by CSB2 that *“they took flood risk. For other weather risks we had to price for extra over items to work in weekends, so if an EWE happened we could accelerate work and recover. So rates for that were agreed beforehand”*.

It was the viewpoint of CSB1 that this approach could lead to *“less project cost, better for clients and fewer disputes”* and therefore was beneficial for both the client and the contractor. Lower overall costs would be incurred by the client in the absence of EWEs and the contractor would not be required to account for EWEs when pricing the work. Similarly, in the event of a EWE disruption, the construction SME was said to be in a beneficial situation, as the risk is the responsibility of the client. Therefore, the approach was considered to be a possible solution that the company is considering to discuss with clients in future projects.

If such a risk sharing measure is not implemented, it was noted that clients will have to be sensible of the disruptions caused by EWEs. This was mentioned as appropriate where a reliable client-contractor relationship exists, but could adversely affect client relationships if the client did not appreciate the disruptive effects of EWEs and the recovery measures

required by a construction SME. If the risk of EWEs increases in the future, it was suggested that construction SMEs may have to consider whether to undertake projects from the clients who were reluctant to consider EWE disruptions amicably. It was claimed by CSB3 that *“maybe learning not to serve clients that do not understand it, if we can, and try to avoid difficult clients could be something we have to consider”*. However, this was seen as an extreme measure, which may not be commercially viable for a construction SME, especially in the current economic climate.

5.2.8 Reasons preventing further measures being implemented

The uncertainty associated with projections of EWE occurrences were identified as a major issue that prevents construction SMEs from undertaking further measures. Summarising the position of CSB, it was claimed by CSB1 that *“we price things and we try to be accurate as much as possible in our estimates, cost plans, etc. So we know if we do this much work this is the amount we will get at the end of the work. But then there is this really big grey area, the weather. You do not really know how bad the weather is going to be. That is a big risk”*. It was stated that as being over cautious could negatively affect competitiveness in their pricing, construction SMEs find it difficult to assess the extent of the risk of EWEs and this has to be reflected in prices quoted. Accordingly, the uncertain and probabilistic nature of EWE predictions was identified as a factor that limits the ability of construction SMEs to determine the extent to which action has to be taken. Therefore, the need for accurate and reliable weather projections was identified as a key requirement. The argument of CSB1 is not without basis; for example the UK Met Office has been criticised for predicting the April – June quarter of 2012 to be “drier than

average”, which in fact turned out to be the wettest in the UK since the records begun in 1910 (Harrabin, 2013).

Whilst it is not a concern for CSB, lack of resources was identified as a potential barrier for construction SMEs in general. It was stated that qualified and experienced professionals are required to integrate EWE risk within estimating and bidding practices, and especially in preparing and submitting claims for approval. Given that significant frequent EWE disruptions were “a kind of a new trend that nobody seems to know much about”, it was mentioned that many of the smaller construction SMEs may not have the resources to prepare claims to recover costs and time associated with EWE disruptions. The need for enhancing the understanding of EWEs among construction professionals has been well established. For instance, following a study of surveyors involvement in flood adaptation Wedawatta et al (2012) confirmed the need for guidance and training programmes for surveyors of flood risk, impacts and adaptation. Lack of clarity in conditions of contract; especially in terms of how to establish whether a particular weather condition is an EWE, contributes to the difficulty in substantiating such a claim, was also identified as a barrier that may affect construction SMEs; especially the smaller SMEs that lack adequate resources as mentioned above.

5.2.9 Information / support requirements

Several information / support requirements were identified by the respondents from CSB, which will be supportive for developing their resilience profile further. One of the requirements was related to conditions of contract. It was mentioned by CSB1 that “*what we would like is better, clearer contracts. Better conditions will definitely help us*”. The concerns of CSB respondents seem to be justified when the conditions governing EWEs in

standard forms of contract used in the UK are examined. Langdon (2012) noted that 88% of construction contracts in the UK are based on JCT (Joint Contracts Tribunal) forms of contract. The JCT forms of contract allow time extensions for EWE disruptions, but do not entitle construction SMEs to claim for cost reimbursements. According to Clause 2.29 (9) of (JCT) 11 Conditions of Contract (The Joint Contracts Tribunal Limited, 2011), “exceptionally adverse weather conditions” is a “relevant event” where a contractor is allowed to request an extension to the project completion date. However, it does not state the criteria for establishing whether a certain weather condition is an exceptionally adverse weather condition.

The next significantly used conditions of contract, New Engineering Contract (NEC) family, was found to be used in 7.4% of projects (Langdon, 2012). The NEC forms of contract, as discussed previously, entitle construction SMEs to claim for both time and cost in relation to EWEs. According to NEC3, clause 60.1 (13) a weather measurement “the value of which, by comparison with the weather data, is shown to occur on average less frequently than once in ten years”. It also goes on to say that “only the difference between the weather measurement and the weather which the weather data shows to occur on average less frequently than once in ten years is taken into account in assessing a compensation event”. However, it was noted by CSB1 that as the UK was affected by back to back heavy winter snowfall in 2009 and 2010, it will be extremely difficult for construction SMEs to establish any future disruption to be a EWE. Therefore it was noted that any subsequent winter disruption will have to be much more severe than that of 2009 and 2010, for it to be categorised as a EWE under the criteria given in NEC3. This has created difficulties for CSB estimating future projects, as it was not clear to what extent

the risk should be factored into estimating, under the current competitive and challenging market conditions / economic climate. Hence, it was noted that better clarity is required in standard forms of contract, in clauses governing EWE disruptions.

In addition to clearer contracts, the need for documenting the impacts of EWEs on construction SMEs was also identified by CSB2. It was stated that *“I presume that summarising on paper the impact of extreme weather on us is important, so people can look at it and see, like say the policy makers can see what may need to change”*. It was noted that there is a dearth of information on how to prepare and cope with EWE disruptions from a construction SME point of view. Given that the UK has been affected by a number of EWEs and as construction SMEs have suffered significant damage as a result, this was thought to be beneficial especially for smaller construction companies. These concerns were also raised by CSA1 (see Section 5.1.9).

As mentioned in Section 5.2.8, the need for accurate and reliable weather projections was also identified as a key requirement. It was noted that reliable weather forecasts will enable construction SMEs to plan their site activities better, minimising potential EWE disruptions. Given that this requirement was raised by CSA1 as well, confidence in existing EWE forecasts seems to be low among construction SMEs. For instance, construction SMEs seem to be of the viewpoint that they were not warned in advance of the severity of heavy snowfalls in 2009 and 2010.

5.2.10 Summary of case study 2

Respondents from CSB recognised the impacts of EWEs on its site activities and the resulting financial impacts on the business as a critical risk to its business activities. A

number of other contributory impacts were also discussed. It was the perception of respondents that CSB has adequately addressed the risk of EWEs within its business planning. The findings from case study 2 (CSB) threw further light on the findings from case study 1 (CSA), and also lead to new knowledge. The CSB case study provided a different perspective coming from a civil engineering stance, as the core business of CSB was in the area of land remediation and earthworks, which are highly susceptible to the effects of weather. For example, the contractual provisions available for construction SMEs in NEC conditions of contract to recover costs associated with EWE disruptions was not discussed in relation to CSA. As noted by CSB3, this element is largely absent in building contracts; in which CSA is specialised in. This can be attributed to the fact that NEC is largely used in projects over £5 million, whereas JCT conditions of contract that is mostly used in projects of lower value (Langdon, 2012) and does not include provisions for recovery of costs related to EWE disruptions.

Analysis of how the EWE risk is currently addressed by CSB shows that it has developed several EWE specific measures, in addition to general risk management practices, that have contributed to resilience to EWEs. Further, most of the measures have traditionally been developed to address weather rather than EWEs; for example general winter conditions rather than extensive snowfall and snow cover lasting a prolonged period. However, following a number of its sites being affected by EWEs during recent years, such strategies have been further expanded to include the risk of EWEs.

The risk assessment exercise conducted for CSB demonstrated that the respondents viewed CSB as being largely resilient to EWEs. Whilst the assessment was a qualitative exercise and categorisation was based on the researcher's interpretation of qualitative

data, it can be seen that CSB was thought to have a higher resilience profile than that of CSA. For example, CSA had 25 high vulnerability, low coping strategies or low coping capacity rankings whereas this figure was 16 for CSB. The respondents of CSB were more optimistic of CSB's ability to manage the adverse impacts of EWE disruptions due to its strong financial position.

5.3 Summary and link

Following the discussion of the findings from the questionnaire survey in Chapter 4, this chapter focused on the findings from the individual case studies. Accordingly, the findings from case studies on CSA and CSB were elaborated, addressing the research questions developed for the study. The next chapter focuses on cross case analysis and synthesis of the individual case studies, drawing from literature and the questionnaire survey findings.

6 CHAPTER 6 – CROSS-CASE ANALYSIS AND SYNTHESIS

The findings from the individual case studies were detailed in the previous chapter. In this chapter, the findings from the case studies and questionnaire survey are synthesised in order to further develop the evidence base for answering the research questions raised at the beginning of the study. Firstly, the findings from the two case study SMEs are analysed comparatively, drawing elements from the questionnaire survey findings as well as the literature review. Secondly, the conceptual framework developed for the study is populated and refined, based on the findings of the study.

6.1 Perceptions of the risk of EWEs

The results of the exploratory survey (see Section 4.3) suggest that the heavy snowfall that affected the UK (and London in particular) in February 2009 (BBC News, 2009) had a major impact on the SMEs in the region. The exploratory survey also suggested that the impacts reported by SMEs are likely to be the ones associated with their most recent EWE experience that had a considerable impact on their business (see Sections 4.3 and 4.4). On a similar note, analysis of EWEs experienced by case-study SMEs (see Section 5.1.2 and Section 5.2.2), showed that much of the discussions were based on the most recent EWE that had affected their business activities. Previous researches undertaken in this area also confirm that the devastation caused by an extreme weather event is likely to be forgotten with time (Lamond and Proverbs, 2006) and members of a community affected by EWEs tend to relate to the most recent experience (Wedawatta and Ingirige, 2012; Wedawatta et al., 2012). This was apparent within CSA as well as CSB. Whilst CSA was affected by heavy snowfall and low temperatures (see Section 5.1.2), CSB was said to have been affected by heavy snowfall, extreme temperatures and flooding (see Section

5.2.2). However, the discussion of impacts, how the risk is currently managed, resilience, and measures that could further enhance resilience etc (see the detailed resilience cues as discussed in Section 5.2.6) were largely focused around the most recent EWE experience; which was heavy snowfall. These findings suggest that the focus of construction SMEs on EWEs is likely to be temporary and is likely to vary depending on their experience during the recent past. Therefore, the level of criticality allocated to EWE risk is likely to change over time and will vary between different EWEs.

Further, as noted in previous research, SME's assessment of the risk posed by different EWEs is likely to be based on past experience rather than as an objective assessment of EWE risk under changing climatic conditions (Berkhout et al., 2004; Norrington and Underwood, 2008). Previous research has also reported that when there is a lack of information or past experience, businesses may underestimate the impacts of EWEs on them or their customers (Berkhout et al., 2004; Frontier Economics Limited, 2013a). It can be argued that this was the case with the questionnaire survey sample, and in fact is the case with construction SMEs in general. Although a majority of the sample have seen their activities affected by EWEs, the events were not seen as having a significant impact on them (see Section 4.4). This was then reflected in SMEs implementing coping strategies to safeguard their businesses against EWEs (see Section 4.7). Therefore, it is important that information is made available to construction SMEs showcasing the potential impacts of EWEs. Case studies such as those of CSA and CSB, whose activities were significantly affected and who have developed a range of risk management strategies, will be beneficial in this regard.

Both CSA and CSB viewed EWEs as a new phenomenon of which construction SMEs are not adequately aware (see Sections 5.1.9 and 5.2.9). Perhaps this explains why the survey sample yielded a response where a major portion did not consider EWEs to be a significant risk or doubted their occurrence (see Section 4.7). Experiencing back to back EWEs in the winters of 2009 and 2010 prompted CSA and CSB to consider EWEs to be a critical business risk that has to be adequately addressed within their business. As the survey was conducted in mid-2009, the significant EWE experienced by the survey sample was the heavy snowfall in 2009 (see Section 4.3). It can be contemplated that the results could have been different if the survey had been conducted in 2010. By then more SMEs would have appreciated the criticality of EWE impacts having been affected by back to back heavy snowfall in that period (2009 and 2010). This perhaps could have resulted in fewer SMEs reporting that EWEs are a minor risk with little probability of their being affected which in turn would result in more SMEs reporting on coping strategies that have been adopted.

Further, the SMEs that responded to the questionnaire survey were predominantly micro sized SMEs (see Section 4.2). Whilst this was largely representative of SME and construction SME populations in general, it was likely that micro sized SMEs would be less active in considering their resilience to EWEs. Sullivan-Taylor and Branicki (2011) argued that organisational size is a key factor contributing towards resilience capabilities that an organisation might possess. Further, micro sized SMEs are less likely to have organised strategies in place to withstand, recover and learn from EWEs than much larger SMEs (Webb et al., 2000; Alesch et al., 2001; Crichton, 2006; Wedawatta et al., 2010). Therefore, it can be claimed that the exploratory survey has yielded a true reflection of

the construction SMEs in general. Examination of case study SMEs with structured response strategies in place produced rich information on how construction SMEs can respond to EWE risk. Lessons learned from case study SMEs can thus contribute to decision making in smaller construction SMEs which are yet to consider the risk of EWEs within their business decision making.

6.2 Impacts of EWEs

The findings of the exploratory survey shed light on the impacts that EWEs have had on those SMEs that were surveyed. For construction SMEs; these have included absence of employees, loss of production, disruption to access, and loss of productivity (see Section 4.4). However, as the options provided in the questionnaire survey were common to SMEs in general, it would not have captured the whole range of impacts on a construction SME. Therefore, the impacts experienced by construction SMEs were investigated in detail in the case studies. These impacts are analysed below under the six main business areas considered in the EWE resilience assessment (see Appendix – H).

6.2.1 Impacts on site activities

Impacts on site activities were identified as the most significant in relation to EWEs. As discussed above, both case study SMEs have experienced lengthy disruptions to their site activities due to EWEs. Respondents interviewed from the two case study SMEs recounted how EWEs had a multitude of impacts on site activities including inability to conduct site activities for a prolonged duration, loss of productivity on sites, delayed project completion, and health and safety concerns for site staff (see Figure 23 and Figure 27). In addition to direct impacts such as those identified above, EWEs have also resulted in wider impacts such as those on client – contractor relationships and contractor – sub-

contractor relationships. It was noted that disputes related to EWEs can adversely affect collaborative working in construction projects and contribute towards adversarial relationships between parties.

It can be observed that particular construction trades have been more affected than other trades. For example, earthworks, brick and block works, and roofing work can be cited as being significantly affected. This was the case with CSBP, given that CSBP was a land remediation project, the activities of the project were stated as heavily dependent on weather, as EWEs such as heavy snowfall, heavy rainfall and flooding affect the ability to conduct earthworks. This is in line with the comments of CSA1, where it was noted that earthworks, as a trade, were especially vulnerable to EWEs such as heavy snowfall and that sub-contractors specialising in such works are some of the most severely affected (see Section 5.1.5.6).

6.2.2 Financial impacts

Not being able to conduct construction work on construction projects for a prolonged period of time can create a number of financial problems for construction SMEs including; loss of revenue, additional costs, loss of profit and negative impacts on cash flow. Such financial impacts were identified as the reason for the closure of construction SMEs following EWEs. Although such financial impacts have had a significant effect on CSA and CSB, they have been able to absorb these costs because of their sound financial position. However, it was noted that many construction SMEs, especially micro and small businesses might not have been able to do so, given their tight operational budgets. This explains why construction SMEs were found to be the business entities reporting the

highest number of closures following EWEs; for example following the Cumbrian floods in 2009 as reported by Wiseman and Parry (2011).

Whilst negative financial impacts were attributed by CSA1 to lengthy EWE disruption in terms of loss of average monthly turnover, respondents from CSB discussed another issue that had contributed to the financial impact of winter EWEs, exerting a significant effect on construction SMEs. It was mentioned that it is the normal practice of construction SMEs to maximise their output and revenue in the summer months to counteract the loss of productivity and revenue inherent in winter months. It was noted that construction SMEs have not been in a position to achieve this during the recent years due to wet summers involving flooding and heavy rainfall (see Section 5.2.5.5). Whilst these disruptions have not been as lengthy as heavy snowfall, the financial impacts of such intermittent events were also noted as high when coupled with other lengthy EWE disruptions.

6.2.3 Supply chain related impacts

Impacts related to the supply chain are considered to be some of the most significant in relation to EWEs (see Section 2.5.2). Whilst supply chain related disruptions such as delays in receiving supplies, loss of utilities and services can be damaging, it can be seen that these issues had less of an impact on case study SMEs, because both CSA and CSB were themselves unable to conduct site activities due to heavy snowfall and low temperatures for a lengthy period. As the site activities were suspended, effects such as the inability to receive supplies (due to the road network or the suppliers being affected by EWEs) or loss of services have not had a significant impact on case study SMEs, in relation to EWEs experienced. However, it has to be noted that such issues could be

disruptive in relation to other EWE situations. For example, a report on the economics of climate change by the Department for Environment, Food and Rural Affairs (DEFRA) recommended the development of practical guidance for businesses to implement supply chain risk management plans, especially for SMEs, and to enhance resilience in their business models (Frontier Economics Limited, 2013b), considering the high vulnerability in this business area.

In the case of CSB, supply chain related impacts experienced were minimal due to the fact that CSB supplied all their own labour, plant and equipment to their projects. This however had a negative impact on CSB as they were required to absorb costs related to loss of work throughout its supply chain (see Section 5.2.3). In comparison, CSA was able to transfer some of the costs down to its supply chain partners; sub-contractors and suppliers (see Section 5.1.3). Therefore, the fact that some of CSA's projects were affected by EWEs has had a negative impact on its supply chain partners.

Further, loss of businesses in the supply chain, as a result of EWEs, is an issue that CSA has experienced. It was noted that the loss of a trusted supply chain partner was particularly damaging in a largely adversarial industry like construction. Survey results also revealed that over 20% of the construction SMEs surveyed had seen their supply chain partners close down following the affects of an EWE (see Section 4.4.1). As discussed in Section 6.2.2 above, this suggests that in recent years EWEs have contributed towards a number of business closures within the industry.

6.2.4 Impacts on workforce

Health and safety concerns were recognised as having a major impact for the workforce in addition to difficult and uncomfortable working conditions. However, both CSA and CSB recognised that the measures are already in place under health and safety procedures to clearly establish the action to be taken in the event of an EWE. Although SMEs in construction are said to be lagging behind larger construction companies in terms of health and safety practices (Arewa and Farrell, 2012), two case study SMEs were conscious of health and safety concerns perhaps being established in medium sized SMEs.

Loss of income / salaries for the period of time in which a business was affected by an EWE was an impact experienced by the site staff of CSA, as their terms of employment allowed CSA to make temporary redundancies during times of low construction activity (see Section 5.1.5.5). This had an adverse impact on site staff financially and on their morale, especially as the loss of income occurred straight after the traditional two week Christmas break. This was not the case with CSB, where the site staff was paid irrespective of whether the site activities were disrupted. Whilst the practice of CSA has enabled a reduction in costs related to EWEs, it has affected the workforce unfavourably. In the case of CSB, the company had to absorb the cost whilst the workforce was affected.

6.2.5 Impacts on market situation

Whilst EWEs have not had much of an impact on the market situation of case study SMEs, it was identified that this could be an important issue in the future, especially with increased occurrence of EWEs. For example, it was recognised that EWE disruptions could lead to disputes with clients. Therefore, certain clients may decide not to offer future work to a particular construction SME, if the performance of that SME is deemed

unsatisfactory by the client. Reputation of a construction SME may also be adversely affected, creating an impact on its ability to attract work. Further, construction SMEs may themselves decide not to work with particular clients, if the risk of EWEs rests entirely with the construction SME (see Section 5.2.7). It was identified that such issues could affect the market situation of construction SMEs.

Further, it was noted that some of the measures implemented to address the risk of EWEs could have an impact on their market. For example, both CSA and CSB recognised the diversity in projects undertaken and procurement of a mixture of projects at any given time as important initiatives which requires further development. Both SMEs recognised that this could have an impact on their market situation, as these initiatives would open new markets as well as reducing sole reliance on and undertaking work within their existing markets.

6.2.6 Impacts on business premises

Whilst the case study SMEs had experienced impacts in relation to their business premises, these were identified more as of an inconvenience rather than having a significant effect on their business activities. CSA and CSB had experienced difficulties in gaining access to their premises following heavy snowfall. Further, it was stated that the business premises of CSB is uncomfortable to work in during the summer when the temperature is high. Whilst these impacts have created inconvenience to employees working in the office, they have not had a significant effect on their ability to conduct day to day activities or on their performance.

Both SMEs were aware that they are not located in a flood-risk area. It was identified that it would have been a cause for concern if this was the case and that the impact of a flood event on business premises could be considerable. Previous research; for example Tierney (1995), Pitt (2008), and Wedawatta et al (2012), have demonstrated that flooding of business premises could lead to a range of impacts including damage to premises and equipment, loss of business records and relocation to alternative premises for a considerable period of time whilst the original premises are reinstated (see Section 2.5.1.1). However, the case study SMEs were aware that their business premises are not at risk of flooding and therefore such impacts is unlikely. Further, as discussed above, the focus for construction SMEs is their construction projects and site activities, rather than their business premises. This is confirmed by the findings from the questionnaire survey, where construction SMEs expressed that relocating premises was less likely in comparison to other SMEs within a flood scenario (see Section 4.10).

6.3 Perceptions of current level of EWE resilience

Discussion of impacts experienced by CSA and CSB in relation to EWEs sheds light on how EWEs are affecting construction SMEs. Whilst the impacts of EWEs have been multifaceted, impacts on site activities and the resultant financial impacts were allocated a higher significance. Both case study SMEs; CSA and CSB, considered EWEs to be a critical risk to their businesses. As discussed in Sections 5.1.4, 5.2.4 and Section 6.1 above, this was mainly due to significant adverse impacts experienced in relation to recent EWEs that have affected their businesses. As a result, the risk of EWEs has been addressed in a number of ways and the SMEs have sought to increase their resilience to EWEs. Case study SMEs therefore considered their businesses as adequately resilient to EWEs. For

example, it was stated by CSA1 that *“yes, I think we are quite resilient as a business”* whereas it was noted by CSB1 that *“I think a diverse business is resilient, and we are a diverse business. So we are a resilient business”*.

Although the two case study SMEs considered their businesses as adequately resilient to EWEs, it was also recognised that future lengthy EWEs have the potential to create a significant impact on their businesses. Therefore, whilst the SMEs were confident of their ability to respond successfully to such an event with the help of measures that are currently in place and their resources and competencies, the need for further improving their resilience was recognised. Both the case study SMEs have already begun assessing some of the options available (see Sections 5.1.7 and 5.2.7); for example CSA has started investigating construction practices in Canada whereas CSB was investigating the possibility of EWE risk sharing methods with other parties in the construction sector. A number of factors that the construction SMEs thought as contributing towards the vulnerability and resilience of construction SMEs were identified in case studies conducted. In addition, analysis of the case study findings revealed further contributing factors. These will be discussed in Section 6.5, in relation to expansion of the conceptual framework developed for the study.

6.4 Support requirements for further enhancing resilience

The findings from the questionnaire survey revealed that the two main reasons cited by the SMEs for not opting to address EWE risk were that EWEs might not affect them in the future and that EWEs will not have a significant impact on their business activities (see Section 4.7). As discussed in Section 4.7 and in Section 6.1 above, such beliefs have been observed among SMEs who have not experienced a significant EWE disruption to their

businesses. Therefore, denial that risk exists and underestimating the risk of EWEs seem to prevent SMEs from enhancing their resilience to EWEs.

Discussions with case study SMEs shed light on issues that prevent construction SMEs from further enhancing their resilience (see Sections 5.1.8 and 5.2.8). These included;

- Perception of EWEs as an unavoidable risk in the construction industry
- Higher costs associated with some of the coping measures (e.g. improving working conditions, alternative construction methods)
- Uncertainty associated with projections of EWE occurrences
- Lack of resources
- EWEs are risks that few construction SMEs were faced with until recently

Therefore, it is important that these aspects are improved in order to make sure that EWE risk is duly considered by construction SMEs in their decision making and appropriate risk management strategies are developed. For example, whilst the risk of EWEs is inherent to the industry given the nature of its operations, discussion of how the case study SMEs have addressed the risk reveals that it is possible to minimise the negative impacts and be a resilient business (see Sections 5.1.5 and 5.2.5). Lack of resources and expertise is often associated with SMEs, due to their inherent size limitations.

In terms of support for construction SMEs, it is important that the restrictions identified above are addressed. In addition, respondents from the case study SMEs also identified the support that SMEs would like to receive in order to further enhance their resilience to EWEs (see Sections 5.1.9 and 5.2.9). For example, even with previous experience,

respondents from CSA and CSB recognised that further information on EWE impacts on construction SMEs and ways and means of addressing the risk would be useful.

Better EWE prediction data was considered to be a requirement in order for construction SMEs to plan site activities better. As discussed in Section 5.2.9, the need for accurate and reliable weather projections was identified as a key requirement. This requirement was raised by both SMEs as well as uncertainty associated with predictions was considered to be a factor preventing further measures being implemented. Confidence in EWE forecasts seems to be low among construction SMEs, as evidenced by the criticism of the UK Met Office for predicting the April – June quarter of 2012 to be “drier than average”, when in fact it turned out to be the wettest in the UK since the records began in 1910 (Harrabin, 2013), suggests that improvement is required in this aspect.

Respondents from CSB highlighted the need for clearer conditions of contract governing EWE disruptions. As discussed in the Section 5.2.9, whilst NEC conditions were identified as more receptive in this regard, it was noted that the conditions stipulated therein to identify whether a particular weather condition is an EWE has made it difficult for construction SMEs to assess what action to take with the risk of heavy snowfall in January – February given the back to back EWEs in 2009 and 2010. It was noted that it would be difficult to satisfy clause 60.1 (13) where there is a requirement to establish that a weather event occurred, on average, less frequently than once in ten years for it to be considered to be an EWE. This has made it difficult for CSB to assess the risk and address it in their pricing and bidding decisions, even though the condition of contract governing EWEs exists.

6.5 Conceptual framework for resilience

As discussed in the Section 2.9.2, a conceptual framework for the study was developed which sought to represent the theoretical basis of how it is proposed to address the research problem defined by the study. Accordingly, the resilience of construction SMEs to EWEs was represented as an effect of vulnerability, coping strategies and coping capacity within a wider supply chain network relating to various EWEs. This then formed the basis for the EWE resilience assessment template developed (see Appendix – G) as a tool that can be used by construction SMEs to assess their resilience to EWEs as well as to collect data for the study. Following the discussion of the findings of the study, it is intended to revisit the conceptual framework and update it, based on the evidence that has emerged from the study. The following sections seek to inform how each of the components of the conceptual framework was expanded to reflect the findings of the study.

6.5.1 Vulnerability

Vulnerability in this study was identified as the characteristics and circumstances of SMEs that determine how susceptible they are to the impact of EW hazards (see Section 2.7.3.1). Through analysis of the findings of the study, a number of factors can be identified as having a major influence on the vulnerability of construction SMEs. These are outlined below.

6.5.1.1 Size of the SME

Vulnerability is often linked with organisational size and consequently smaller businesses are often identified as more vulnerable to disruptions (see Sections 2.4.1, 2.5). Case study respondents reported that EWEs that affected their businesses had a bigger impact on

smaller construction companies (see Sections 5.1.3, 5.1.4, 5.2.3 and 5.2.4). Previous research has also reported vulnerability to EWEs as being strongly linked with the size of businesses and that smaller business as more vulnerable to EWEs (Dahlhamer et al., 1999; Crichton, 2006; Runyan, 2006; Tierney, 2007). As discussed by Sullivan-Taylor and Branicki (2011), due to the impact of organisational size on the resilience capabilities of an organisation, one size of regulation or advice is unlikely to fit all business organisations. Therefore, size of a SME can be identified as an influential factor that contributes towards vulnerability to EWEs.

6.5.1.2 Business specialisation

The findings from the case studies established that SMEs specialising in certain trades to be more vulnerable to EWEs (see Sections 5.1.4, 5.2.4, and 5.2.5.2). This was confirmed by respondents from both the case study SMEs. For instance, CSA1 and CSAP1 highlighted that sub-contractors specialising in roofing work, ground work, and wet trades including brick work, block work and concrete work were some of the trades significantly affected by EWE disruptions (see Section 5.1.4). Similarly, CSB1 confirmed earthworks to be a trade significantly vulnerable to EWEs. Further it was noted that some of the construction SMEs specialising in earthworks alone have struggled following EWEs and that CSB has been able to avoid such difficulties due to it being a diverse business (see Section 5.2.5.2). Therefore, business specialisation can be identified as a factor contributing to the vulnerability of construction SMEs.

6.5.1.3 Diversification and spread of projects

Langdon and Male (2001) identified five reasons for diversification in construction firms; increasing profitable growth, seeking diverse activities where profitable growth can be

achieved, increasing efficiency through supply chain control, use of positive cash flow, and to avoid construction cycles, particular clients and markets. The findings from this study suggest that construction SMEs have found diversification to be an effective strategy that enables them to limit the adverse impacts of EWEs on their businesses (see Section 5.1.5.2 and 5.2.5.2). Therefore, case study SMEs are said to be looking to further expand their diversification strategies and achieve a greater spread of construction activities, to counteract potential adverse impacts of EWEs. Therefore, whilst diversification has evolved primarily as a commercial strategy, as identified by Langdon and Male (2001), construction SMEs seem to consider diversification as a way of enhancing their resilience to the increased risk of EWEs. Hence, the findings from the study add a further reason for diversification by construction SMEs; to reduce their vulnerability to EWEs and increase their resilience against EWEs.

6.5.1.4 Extent of subcontracting / individual supply chain

The case of CSA demonstrates how its sub-contracting practices have enabled CSA to transfer some of the costs of EWEs down to its sub-contractors (see Sections 5.1.3 and 5.1.5.6). This has made CSA less vulnerable to damages from EWEs. Conversely, CSB's policy of supplying all plant, labour to its projects and not sub-contracting any work has increased its vulnerability to damages in the event of an EWE (see Section 5.2.3). As a result of not being in a position to transfer the costs to its sub-contractors or plant suppliers, CSB was required to absorb the total cost of disruption on its own. This suggests that sub-contracting is likely to reduce vulnerability whereas having an in-house supply chain is likely to contribute towards vulnerability of a construction SME.

A counter argument to this would be that sub-contracting increases the probability of sub-contractors; especially those specialised in vulnerable trades, of being involved in the supply chain closing down as a result of EWE impacts, thus creating an indirect impact on a construction SME. Further, as the literature suggests (see Sections 2.5.2 and 2.6), complex supply chains with several parties further increases that risk. Therefore, it can be seen that sub-contracting practices could also increase the vulnerability of construction SMEs.

6.5.1.5 Location of projects

Location of business premises was not identified as a concern for construction SMEs (see Sections 5.1.6 and 5.2.6). This, as discussed in Section 2.6, is the point of departure at which construction SMEs differ from other SMEs such as those in the retail and real estate sectors. In comparison, what is of significant concern for construction SMEs is the location of their construction projects? Where the projects are and the EWEs affecting that region is likely to have a bearing on the vulnerability of a SME to EWE. For example, CSA1 cited how weather conditions that affected one of the projects executed in Scotland, which were thought as extreme by CSA, were not recognised as EWEs by the client's representative as such conditions are common to the region.

6.5.2 Coping strategies

The definition of coping strategies adopted in this study was "actions that increase the ability to prevent, tolerate and/or recover from the impacts of EWEs" (see Section 2.7.3.3). Findings from the questionnaire survey, and more importantly the case study research, identified a range of coping strategies implemented by construction SMEs to manage the impacts of EWEs on their businesses. Some of the strategies discussed were

focused at organisational level whereas others were focused at project level. Further, some of the strategies were general risk management / business continuity strategies whereas others have been specifically developed to address the risk of EWEs. Accordingly, coping strategies can be broadly categorised based on their focus; i.e. those focused at project or organisational level, and based on the risks that they seek to address; i.e. business / continuity risks in general or EWE risk specifically. This categorisation is depicted in Figure 30. The following sections outline each of the categories identified therein.

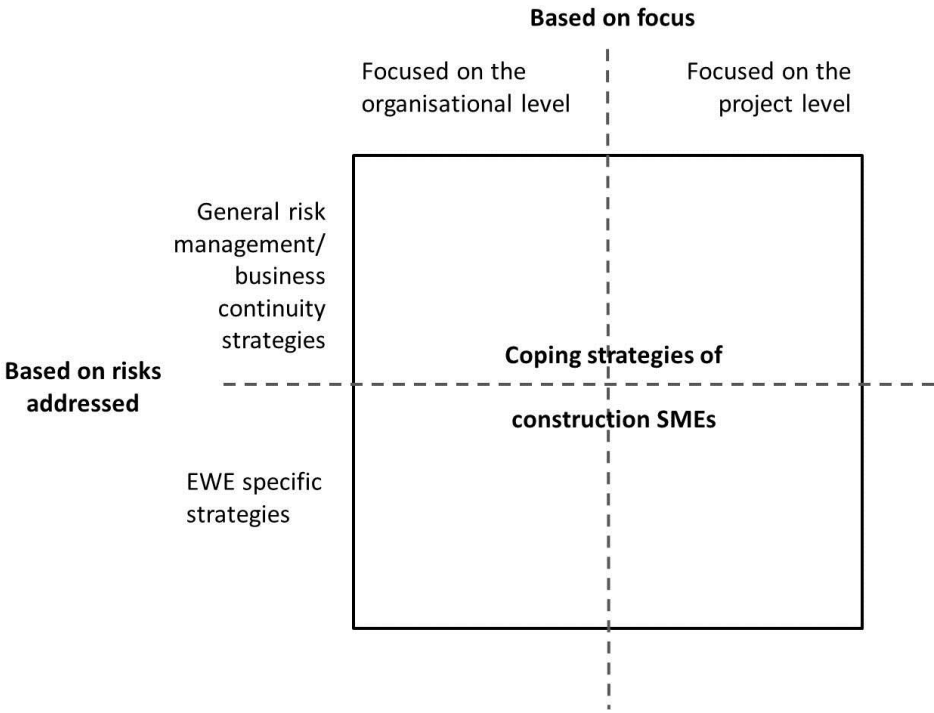


Figure 30 - Categorisation of coping strategies of construction SMEs

6.5.2.1 General risk management / business continuity strategies

Some of the coping strategies that the construction SMEs have found useful were general risk management / business continuity strategies implemented within the businesses. Although these have not been implemented specifically to cover the risk of EWEs, having

such strategies in place has enabled SMEs to prevent, withstand and recover from EWEs better. For example, strategies reported by construction SMEs subjected to the questionnaire survey include such matters as data backup plans and business continuity plans (see Section 4.5). Strategies reported by CSA, such as sub-contracting practices, terms of labour employment and business continuity planning, in addition to the strategies reported by CSB such as business diversification and project meetings, are generic risk management strategies implemented to reduce risk, ensure business survival and commercial advantage. Therefore, it is evident that some of the general risk management / business continuity strategies implemented in construction SMEs could effectively contribute towards their resilience to EWEs.

6.5.2.2 EWE specific strategies

However, general risk management strategies alone, as discussed above, may not provide an adequate level of resilience against EWEs. Considering this, the case studies revealed that SMEs have extended general risk management strategies or implemented new strategies specifically addressing the risk of EWEs. In the case of CSA and CSB, these included considering EWE risk in bidding, estimating, and project planning, and usage of conditions of contract (see Figure 26 and Figure 29). Evaluation of these strategies; for example considering EWE risk in project planning, shows that such EWE specific strategies to be essential in combination with general risk management strategies, if a construction SME is to achieve a good level of resilience to EWEs.

6.5.2.3 Coping strategies at project level

Case study findings revealed that the focus of construction SMEs, in regard to EWEs, was mostly on the projects that they undertake. EWEs affecting their projects have created a

significant impact on construction SMEs. Consequently, many of the coping strategies that have been implemented focused on construction projects. For instance project pricing, bidding and planning strategies, conditions of contract, sub-contracting practices, and methods of construction can be cited (see Figure 26 and Figure 29). Given the potential of EWEs to disrupt site activities for prolonged durations as well as intermittent disruptions that can also have a significant impact on construction SMEs, it is important that the risk is adequately addressed at project level.

6.5.2.4 Coping strategies at business level

Whilst a majority of the strategies found in case study SMEs were focused on construction projects, some of the strategies discussed were implemented at business level. For instance, business continuity planning and commercial strategies such as diversification can be cited (see Figure 26 and Figure 29). As was recognised by the case study SMEs, whilst their businesses were thought to be resilient to EWEs it was also recognised that a future EWE may have the potential to affect the activities of their businesses irrespective of the measures that are in place (see Sections 5.1.6 and 5.2.6). Therefore, it is important that the risk is also addressed at business level to account for the resultant impact on the business as a whole and its continuity. Lack of coping strategies at the business level may, perhaps, be argued as a reason for construction SMEs reporting high business failure rates as a result of EWEs. Whilst the case study SMEs demonstrated such coping strategies at the wider business level, many of the smaller SMEs might not have such strategies in place. For instance, the questionnaire survey reported lower percentages of construction SMEs with business continuity insurance;

business continuity planning or property-level protection strategies (see Sections 4.5 and 4.6).

6.5.2.5 Categorisation of coping strategies

Based on the analysis above, the coping strategies of construction SMEs can be subdivided in to four quadrants, based on their focus and the risks that they seek to address;

- General risk management strategies focused at business level
- General risk management strategies focused at project level
- EWE specific strategies focused at business level
- EWE specific strategies focused at project level

These are depicted in each of the quadrants in Figure 30. Coping strategies observed in case study construction SMEs seem to suggest that most of the strategies implemented by construction SMEs currently fall into the category of EWE specific strategies focused at project level, whilst less attention has been paid to the other three types of coping strategies. It can be argued that a resilient construction SME will demonstrate coping strategies falling into each of the quadrants, based on their requirements. It is important that a construction SME implements a suitable mix of strategies to achieve the required level of resilience. For example, EWE specific coping strategies at project level can minimise disruption to site activities. However, as noted by construction SMEs (see Section 6.3), site activities might still be disrupted by EWEs despite such measures being in place. Therefore, other types of coping strategies at business level are required to address the remaining risk and cope with the impact that disrupted site activities will

have on the rest of their business. It may be argued that the lack of coping strategies to cover different types of risk, as identified above, is a reason leading to why EWEs have such a severe impact on construction SMEs and threaten their continuity. Categorisation, identified above, presents a novel approach to presenting the coping strategies of construction SMEs, and suggests the importance of having a broad mix of coping strategies in place pertaining to each type of coping strategies identified.

6.5.3 Coping capacity

In this study coping capacity was identified as the ability of a SME to limit the adverse consequences of EW hazards, using available resources and capabilities (see Section 2.7.3.3). As noted by Linnenluecke and Griffiths (2010), to build resilience, organisations need to develop multiple capabilities and response approaches. The following subsections highlight some of the key factors affecting the coping capacity of a construction SME, as emerged through the findings.

6.5.3.1 Previous EWE experience

The findings from the questionnaire survey and case study research suggested that previous EWE experience to be a key criterion that determines the coping capabilities of a construction SME. Findings confirmed that construction SMEs are likely to implement coping strategies and address the risk of EWEs within their business decision making after being affected by an EWE (see Sections 5.1.5 and 5.2.5). Further, they were also found to be willing to investigate and invest in further strategies (see Sections 5.1.7 and 5.2.7). Such measures that are put in place and the experience of managing the issues surrounding a previous EWE is likely to enhance the ability of a construction SME to respond to a future EWE more effectively.

6.5.3.2 Established nature of a SME

It was noted by both construction SMEs that being an established business with a reliable track record, rapport and established relationships has aided them to withstand the adverse impacts of and recover following EWEs (see Sections 5.1.6 and 5.2.6). The established nature of a SME leads to other aspects such as the ability to negotiate with a client (for e.g. risk sharing strategies), established client – contractor relationships (e.g. clients being sensitive to EWE disruptions to construction work, fewer disputes regarding EWEs), the ability to be selective in bidding for construction work (e.g. avoiding difficult clients, avoiding highly vulnerable projects), less impact on ability to attract projects, etc. It can be noted that these issues have contributed to the coping capacity of the two case study SMEs, due to their being well established businesses with solid track records.

6.5.3.3 Financial resources available

Whilst the costs associated with EWE disruptions had a considerable impact on the finances of case study SMEs, they have been able to absorb these costs and manage the financial impacts due to the strong financial position of their businesses (see Sections 5.1.6 and 5.2.6). It was noted by the case study respondents that smaller construction SMEs in a less strong financial position would not have been able to do so, and it was noted that many such construction SMEs would have closed down as a result. Resilience assessments completed following the extended interviews with case study SMEs revealed that whilst financial impacts of EWE disruption was identified as a key issue, SMEs believed that their strong financial position would contribute towards their resilience (see Sections 5.1.6 and 5.2.6). Therefore, the ability to absorb the costs of EWEs and other financial impacts (see Sections 5.1.3 and 5.2.3) using the financial resources available to a

construction SME seems to significantly contribute towards their coping capacity and thereby resilience.

6.5.3.4 Availability of expertise

Case study SMEs recognised that expertise is required to comprehend the conditions of contract surrounding EWEs, raise claims as well as make informed bidding, pricing and project planning decisions. Even with an adequate level of expertise being available within their businesses, CSA and CSB have found it difficult to assess the conditions of contract governing EWEs and assess the risk of EWEs (see Sections 5.1.8 and 5.2.8). It was noted that construction SMEs who do not have such expertise will struggle as a result to factor EWE risk into pricing and bidding strategies, substantiating claims, etc. Both SMEs therefore recognised their qualified workforce to be a factor that contributes towards their resilience (see Sections 5.1.6 and 5.2.6).

6.5.3.5 Experience of senior management

Sullivan and Branicki (2011) discussed the limitations of applying a one-size-fits-all organisation solution to creating resilience within businesses, and recognised that the unique nature of business organisations necessitate unique solutions applicable to that organisation. However, for a construction SME to arrive at a suitable resilience strategy, senior management and employees experienced in issues concerning EWEs will be required. Further, experience and perceptions of the senior management plays a crucial role in business decision making within SMEs (see Sections 2.4.1 and 2.4.2). Norrington and Underwood (2008) noted how the perspectives and experiences of SMEs senior management significantly drive the decision making process related to extreme weather and climate change. In a similar vein, the fact that senior management from the two case

study SMEs were keen to address the risk of EWEs within their businesses seems to have contributed towards their resilience strategy. If senior management are in denial about the risks; as is the case with many construction SMEs (see Section 4.7), such strategies might not be implemented.

6.5.4 External factors

Business organisations operate in a dynamic environment consisting of social, economic, and political environs. Therefore, these external factors are likely to have an impact on the resilience of construction SMEs. For example, changes in policy governing climate change adaptation or flood adaptation can be cited. The major external factor that emerged as influential in the study was the wider economic climate. It was noted by case study respondents that the tighter economic situation prevailing in the UK at the time has contributed towards EWEs having a significant impact on construction SMEs (see Sections 5.1.3, 5.1.4, 5.2.3 and 5.2.4). As noted by Price et al (2013) and Eadie et al (2013), the recession that prevailed in the UK in 2008 – 2009 had major consequences on the construction industry, and construction SMEs in particular. Therefore, this has adversely affected the resilience of construction SMEs to the EWEs that affected them during the time of recession and the prolonged period of low economic growth that followed. Hence, the wider economic climate can be identified as a major external factor that affected the resilience of construction SMEs to EWEs. Among others, similar findings were reported by Tierney (1994) and Webb (2000).

6.5.5 Feedback

It is important that lessons learned from EWE experiences are reflected in future decision making. As the evidence suggests, construction SMEs are likely to alter their way of

addressing the risk once the impact of an EWE is experienced. Furthermore, vulnerabilities, effectiveness of strategies in place and coping capabilities will only become evident following the experience of an EWE. Therefore, an SME will be in a position to address the weaknesses observed in relation to an EWE by incorporating the lessons learned in relation to that EWE experience within its business planning. Therefore, the feedback loop in the framework is an important element that highlights the significance of revisiting existing strategies and incorporating lessons that can be learned from a particular EWE during the aftermath.

6.5.6 Characteristics of EWEs

In addition to organisational factors, the characteristics of EWEs that affect SMEs also seem to contribute towards their resilience to such events. The impact that the characteristics of EWEs have on organisational resilience has been recognised in previous literature. For example, Cutter et al (2008) identified event characteristics as a key component of disaster impact and resilience. Based on the findings of the study, three main event characteristics can be identified as determining the resilience of a construction SME as outlined below.

6.5.6.1 Type of EWE

It was noted by case study respondents that high temperatures and heat wave conditions were more of an inconvenience to site and head office staff, which had minor implications on the business (see Sections 5.1.3 and 5.2.3). These have included the need for additional environmental controls and uncomfortable working conditions, but not significant disruptions to work or major financial impacts. However, prolonged disruptions associated with heavy snowfall and low temperatures were identified as

exerting severe impacts on construction SMEs. Heavy rainfall was also noted by the respondents of CSB as particularly damaging (see Sections 5.2.8 and 5.2.9). Therefore, impacts associated with different EWEs seem, to a certain extent, to be different.

6.5.6.2 Timing of EWEs

This suggests that the time of year when the EWE strikes and the duration that the EWEs affect business plays a crucial role in determining the extent of the impact on a business. This has also been noted in previous research in relation to other SMEs. For instance, Wedawatta et al (2012) noted how being flooded in the pre-Christmas period has had a critical impact on retail SMEs. Further, it was recently reported how the heavy snowfall in March 2013 has had a severe impact on farming and livestock SMEs, as the event occurred during the lambing season, which was said to be a key period for farming (BBC News, 2013). On a similar note, the pre and post-Christmas period can be identified as a key time period for construction SMEs, because of the two-week Christmas break and productivity losses before and after the Christmas as noted by CSA1 (see Section 5.1.3.3). Further, summer months where construction SMEs expect to intensify their construction activities also seem critical as weather disruptions in this period can have a significant impact on their project completion and income. This was pointed out by CSB1, *“what you have got to do in the summer is to get everything out earning and doing more work, say from 7 till 7. And then you store a little bit of cash. And then in the winter it is a way out of it and hopefully you will still be in a positive position. But I do not think that has happened in the last five years. I do not think we have had a good summer in the last five years”*.

6.5.6.3 Duration

The duration of EWE disruptions was identified as a factor that contributes towards resilience of construction SMEs. Highlighting this, it was stated by CSA1 that *“if flooding happens we will not possibly be able to work, not for a sustained period of time. Severe weather conditions that we are used to here, you may get severe downpours, but it dries out very quickly, so you are able to carry on. Intermittently you may lose a number of days in month, rather than weeks. What was quite debilitating was the snow, because it stays, it lasts, you cannot see the ground, so the sites are dangerous for weeks”*. As noted by CSA1, not being able to generate income from projects over a lengthy period of time can cause significant financial implications to construction SMEs, even leading to business failure (see Section 5.1.3). Whilst identifying that even intermittent EWEs of short duration can be costly, especially during times when extra resources are required on site to accelerate work and recover time lost due to a previous EWE (see Section 5.2.3.1), the relationship between the duration of an EWE and its impact, especially financial impact, was also pointed out in the discussions with respondents from CSB.

6.5.7 Updated conceptual framework

Based on the findings of the study, as discussed above, the conceptual framework developed during the course of the study can be updated as shown in Figure 31. Adoption of the risk assessment template based on the conceptual framework prepared during the data collection and analysis stages of the study validated the applicability of the concepts behind the conceptual framework both theoretically and in practice. Further, the conceptual framework was further expanded to reflect the overall findings of the study. Accordingly, the key criteria for vulnerability, coping capacity, coping strategies and

characteristics of EWEs that contribute towards the level of resilience were included within the conceptual framework. As discussed above, the criteria for vulnerability included the size of the SME, specialisation, diversification and spread of projects, extent of sub-contracting, and location of projects (see Section 6.5.1). The key criteria that determine the coping capacity of a construction SME were identified as previous EWE experience, how well established the SME is, financial capacity, availability of expertise, and experience of senior management (see Section 6.5.3). Coping strategies were sub-categorised based on the risks that they seek to address and whether they are focused on construction projects or at organisational level (see Section 6.5.2).

The wider economic climate was included as an overall key factor to reflect its influence on the level of resilience of SMEs following the discussions and analysis of case study findings. Similarly, analysis of the case study findings pointed to certain characteristics of EWEs; type of EWE, and timing and duration, as having a key influence on the resilience of construction SMEs. Accordingly, event characteristics and the wider economic climate which were not part of the initial conceptual framework were included based on the findings of the study. Therefore, the resilience of a construction SME to EWEs can be seen as a collective effect of the vulnerability, coping strategies and coping capacity of the SME and its supply chain, characteristics of the EWE and the wider economic climate.

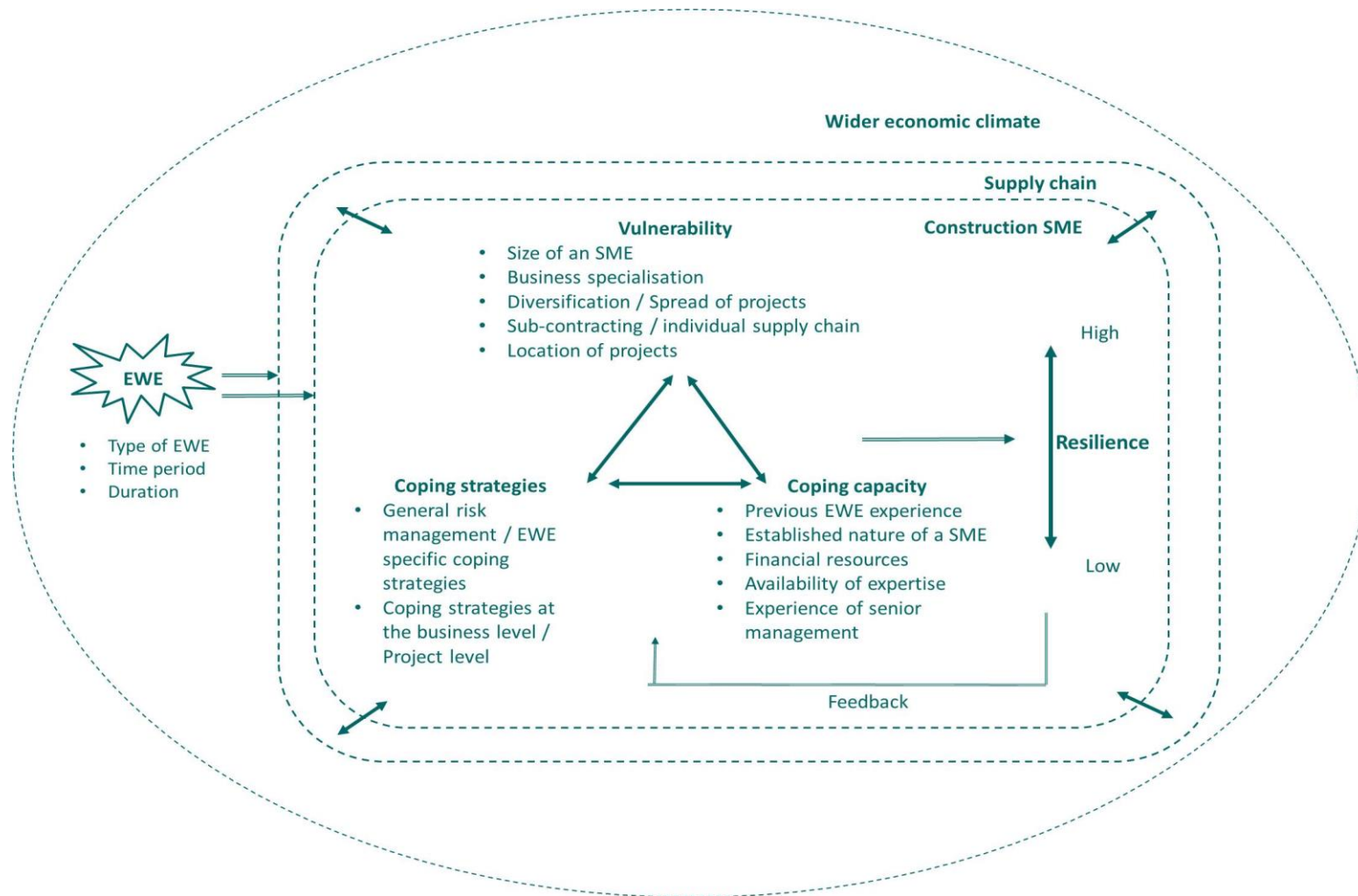


Figure 31 - Updated conceptual framework

Accordingly, the starting point of the framework is the characteristics of an EWE. The characteristics of the EWE will contribute towards the impacts that it has on a construction SME and / or its supply chain. The level of resilience a particular construction SME can achieve against those impacts will depend on its vulnerability, the coping strategies that are in place and its inherent coping capacity. The external factor of the wider economic climate will have a bearing on the level of resilience the SME can achieve. Whilst the framework is based on the conceptual underpinnings of how resilience was perceived at the beginning of the study (resilience as a collective effect of vulnerability, coping strategies and coping capacity within a complex supply chain network), it is grounded within the context of construction SMEs as the expanded framework was informed by the empirical findings that emerged from the study.

6.6 Summary and link

Following the discussion of questionnaire survey findings in Chapter 4 and findings of the individual case studies in Chapter 5, this chapter sought to analyse the findings across the cases and to synthesis those findings. The conceptual framework developed for the study was also updated and populated based on the findings that emerged from the study. The next chapter seeks to further synthesise the findings and re-visit the objectives of the study to ensure that the objectives of the study are achieved.

7 CHAPTER 7 – CONCLUSIONS

7.1 Introduction

The previous chapter presented a cross-case analysis and synthesis of case studies referring to the questionnaire survey findings and key literature. Based on the findings that emerged through the data analysis, the conceptual framework developed for the study was amended and expanded. Following the discussions in relation to the literature, questionnaire survey findings, case study-findings and cross-case analysis in the previous chapters, this chapter seeks to provide an overall synthesis of the study. Accordingly, in this chapter, conclusions are arrived at by summarising the results of the overall study. For this purpose, each objective of the study is revisited and the research questions raised in connection to the objective are addressed. Next, the contributions that the study makes to theory and practice are identified. The chapter is concluded by identifying the limitations of the study and recommended future research directions.

7.2 Synthesis of objectives of the study

As set out in Section 1.2, it was identified that the issues with regard to resilience of construction SMEs to EWEs have only been subjected to limited in-depth academic research. This study was undertaken to address the obvious gap between the increased need for improving the resilience of construction SMEs to EWEs and the current knowledge with regard to this issue. Accordingly, the study aimed to undertake a detailed investigation into the resilience of construction SMEs to the impacts of EWEs (see Section 1.4). In order to achieve this aim, five key objectives were set. The following sub-sections outline how each of those objectives was achieved in the study.

7.2.1 Objective one

The first objective of the study was *“to examine the impacts of EWEs on SMEs in construction and other industry sectors”*. Whilst a number of studies have looked at impacts of EWEs on SMEs during recent years (see Section 2.5.1), not many have investigated the impacts of EWEs on construction SMEs specifically. Accordingly, the study sought to investigate the current affects of EWEs on construction SMEs. The literature review conducted revealed some of the common impacts of EWEs on SMEs in general (see Section 2.5.1). These were taken forward in the questionnaire survey in which the SMEs involved were questioned on how they had been affected by EWEs during past years (see Section 4.4).

The construction SME case studies confirmed that the impacts of EWEs are multi-faceted (see Section 6.2). Whilst impacts have been felt on a number of aspects of their business activities, disruptions to site activities and the resultant financial impacts were allocated the highest significance (see Sections 5.1.3 and 5.2.3). This impact is highly related to the financial health and well being of construction SMEs and hence they seemed to react to this quite quickly. The financial impact caused by loss of income and additional costs was highlighted as the cause for the liquidation of many construction SMEs as a result of the effects of EWEs. The case study findings suggested that restricted economic conditions have contributed towards the financial impacts associated with EWE disruptions creating an aggravated effect on financial situation of construction SMEs.

Analysis of EWE impacts on the two case study construction SMEs provided a comprehensive account of how different impacts trigger other crises and how the effects on construction projects cascade down through the business as a whole. The findings

confirmed that SMEs are unlikely to react to the EWEs unless there is some record of previous experience of EWEs (see Section 6.2). The case study respondents also noted that there is a general lack of understanding among construction SMEs about the possible impacts of EWEs. The findings of the study can therefore provide construction SMEs with an understanding of the possible impacts of EWEs, thus allowing them to relate such impacts to their own businesses and consider addressing the risks posed.

7.2.2 Objective two

The second objective of the study was *“to identify construction SME perceptions of EWE risk and their impacts”*. The questionnaire survey findings revealed that the risk of EWEs was not considered to be a critical risk by construction SMEs (see Sections 4.7 and 6.1). This can be considered to be representative of construction SMEs in general, and in fact SMEs in general, who do not have past experience of such events. Although some of the survey respondents had experienced such events, the impacts had not been significant and as a result the risk of EWEs was not considered significant.

In contrast however, the two case study SMEs considered EWEs to be a critical risk to their businesses (See Sections 5.1.4, 5.2.4, and 6.1). This was primarily due to significant adverse impacts experienced in relation to previous EWEs during recent years by the case study SMEs, in contrast to the SMEs surveyed whose EWE experiences were not as devastating. The case study SMEs were therefore appreciative of the difficulties associated with EWEs and the necessity to adequately address the risk in their business decision making. This has resulted in two case study SMEs developing a range of strategies to address the risk of EWEs within their projects and their businesses and were also aware of the need for further improving and expanding their existing measures. This

suggested that construction SMEs with previous experience of significant EWE impact were fully prepared and active in addressing the risk. The behaviour of construction SMEs was therefore said to be reactive rather than proactive in accepting the risks posed by EWEs. This suggests the post-EWE scenario as being the ideal opportunity for dissemination of advice among construction SMEs, as they are likely to be receptive to such advice when the impacts of EWEs are visible. EWE affected SMEs can also be change agents through whom such advice can be disseminated across its supply chain and to other SMEs in close contact who might not have personally experienced EWEs. This is because the experience of that SME could help others to relate EWE impacts to their own business and prompt a response.

7.2.3 Objective three

The third objective of the study was *“to evaluate how the EWE risk is addressed by construction SMEs”*. Some of the common strategies implemented by SMEs in general were discussed following the review of existing literature (see Section 2.5.3). However, the findings of previous researches have reported adoption of such strategies to be low among SMEs. On a similar note, the findings of the exploratory questionnaire survey revealed that many of the construction SMEs have not implemented such measures (see Sections 4.5 and 4.6). Furthermore, construction SMEs were found to be less proactive in addressing the risk of EWEs when compared to other SMEs. However, the structured responses provided in the survey template were common to SMEs in general, and therefore, might not have captured some of the strategies unique to construction SMEs.

This issue was, therefore, addressed in-depth in the case studies. The case studies revealed the different ways in which construction SMEs address the risk of EWEs (see

Sections 5.1.5 and 5.2.5). These included bidding and pricing strategies, project planning, risk transfer to employees and sub-contractors, business diversification, and business continuity planning. As the focus of construction SMEs was placed on their projects, most of the strategies were targeted on projects undertaken by SMEs whilst some of the strategies were focused at business level. In terms of projects, planning for potential EWEs in the early stages of a project can be identified as important. Case study SMEs recognised the need for addressing the risk of EWEs in deciding to bid for a project, pricing work, determining methods of construction and in project planning. Whilst such strategies could minimise the impacts in the event of an EWE, case study SMEs recognised that the risk of EWEs to their projects is difficult to completely eliminate. Therefore, the findings of the study also highlighted the need for addressing the risk at business level as well, as project activities might still be affected despite the measures implemented.

7.2.4 Objective four

The fourth objective of the study was *“to assess the key issues that affect the resilience of construction SMEs to EWEs”*. This objective was achieved primarily through the analysis of case study findings and was supported by the existing literature. As resilience in the study was seen as an effect of vulnerability, coping strategies and coping capacity (see Section 2.9), key issues pertinent to these three concepts were analysed. Accordingly, key criteria for vulnerability, coping strategies and coping capacity that emerged from the findings of the study were discussed in the Section 6.5. External factors such as the characteristics of EWEs and the wider economic climate were seen as having a significant influence on the resilience of construction SMEs. Therefore, these factors were included within the

conceptual / theoretical framework for resilience of construction SMEs (see Figure 31). Accordingly, the conceptual framework developed for the study was revisited and expanded to reflect the findings that emerged from the study.

7.2.5 Objective five

The fifth objective of the study was *“to develop a decision making framework that can be used by construction SMEs to improve their resilience to EWEs”*. This objective was achieved by developing a resilience assessment template (see Appendix – H). The template was influenced by the existing UKCIP BACLIAT tool and was an expansion of BACLIAT to reflect the risk of EWEs on SMEs. The concept of achieving resilience by reducing vulnerability, implementing coping strategies and enhancing coping capacity was incorporated into the resilience assessment template. A list of questions were developed which can act as prompts to generate discussion about different aspects included in the resilience assessment template (see Appendix – G).

The template was then validated using the expert opinion approach (see Section 0). Question prompts were developed to complement the resilience assessment template, the answers to which will lead to discussions on and generate information for completing the assessment for different business areas of a construction SME. These question prompts were used as the interview guidelines for extended interviews conducted with the case study SMEs. This approach enabled the attainment of rich data for qualitative analysis as well as for conducting an assessment of resilience using the template. Accordingly, resilience assessments were completed for the two case study SMEs (see Appendix – I and Appendix – J). The completed assessments can act as exemplary cases that other construction SMEs can refer to and relate to their own business situations.

7.3 Contribution to theory and practice

The study makes a noteworthy contribution to theory and practice in the subject domain of resilience of construction SMEs to EWEs as outlined in the subsequent sub-sections.

7.3.1 Multidisciplinary research study

Puddicombe and Johnson (2011) highlighted the need for building on the work of other disciplines and applying the work in the specific context of the construction industry as the way forward to enhance the understanding of the issues relevant to the industry. This involves studying other knowledge domains in relation to the construction industry. Furthermore, research pertinent to construction is encouraged to be multi-disciplinary (EPSRC, 2013). This allows further development and application of knowledge from other disciplines than construction. The study answers these calls for multi-disciplinary research and application of wider scientific knowledge within construction management research by investigating a research issue that involves a number of disciplines such as disaster management, climate change adaptation, resilience to EWEs, SMEs, organisational resilience, business continuity.

7.3.2 Relocation of literature

Koskela (1996) characterised theory in construction as being a synthesis of several related disciplines and remaining construction core particularities that are not covered elsewhere. The gap in the knowledge identified for this study, lack of research on construction SMEs' response to EWEs, falls in line with this comment. Knowledge in regard to resilience of construction SMEs to EWEs was scattered across a number of knowledge domains; including SME (small business) management, construction

management, disaster management, climate change adaptation, organisational resilience, and risk management in regards to the resilience of SMEs. However, there was a gap in the knowledge of how this knowledge applies to construction SMEs; which this study sought to address. Therefore, knowledge dispersed across a number of key disciplines with regard to the resilience of construction SMEs was positioned within the construction management body of knowledge. Further, the study also contributes to these other knowledge domains by contextualising the perspective of construction SMEs.

7.3.3 Conceptual framework

The conceptual framework developed for the study (see Figure 31) contributes to theory by conceptualising a novel approach to represent the resilience of SMEs to EWEs. The initial conceptual framework that was developed introduced the theoretical proposition of representing the resilience of SMEs as a collective effect of vulnerability, coping strategies and coping capacity. The framework was revisited and expanded following the analysis of primary data. The expanded conceptual framework represents key criteria for vulnerability, coping strategies and coping capacity of construction SMEs, based on findings of the study (see Section 6.5.7). Therefore, the conceptual framework introduces a novel concept of resilience from a construction SME perspective, which is influenced by existing theories on resilience and related issues but grounded within the context of construction SMEs. The conceptual framework can, therefore, act as a useful tool for policymakers and business support organisations in developing strategies towards enhancing the resilience of construction SMEs to EWEs, as the framework represents key aspects of resilience from a construction SME perspective.

7.3.4 Resilience assessment template

A resilience assessment template was developed that can be used by construction SMEs as well as other SMEs as an aid to realise their current level of resilience to EWEs and identify business areas that need improvement; in the areas of vulnerability, coping strategies and coping capacity (see appendix – H). This exercise, once completed, can be performed periodically as a live tool or following an EWE to assess changes and address the required areas of resilience. The practical usability of the tool is further emphasised by the fact that it has originated from a wider toolkit maintained by the UKCIP, thus allowing SMEs to access further information. The risk assessment template developed can be used either within a wider business continuity plan or as a standalone EWE risk assessment exercise at business level or as part of the risk register in a construction project. Adaptation of the BACLIAT toolkit for the purpose of the study has also been recognised by UKCIP (2011). Since the inception of this study similar tools have been developed by business support organisations such as Business in the Community North East (2011) and Business Link (2011) and such tools are becoming popular among SMEs due to the government's strategy to encourage businesses, especially SMEs, to adapt to EWEs such as flooding and changing climatic conditions. Whilst such tools focus on climate change, the resilience assessment template developed in the study focuses specifically on EWEs. The assessment is less cumbersome and offers flexibility for construction SMEs to interpret how different aspects of resilience relate to the context of their own businesses.

7.3.5 Case studies of EWE impacts and good practice

As noted by Berkhout et al (2004), one of the complications that contribute to apathy of construction SMEs in relation to EWE preparedness is their inability to relate to the impacts that EWEs could have on their business activities. The findings of the exploratory survey also revealed that many of construction SMEs believed that EWEs would not have a significant impact on their business activities. However, SMEs with previous EWE experience appreciated that EWEs could have a critical impact on their business activities and highlighted the strategies that they have adopted to enhance their resilience. These case studies could provide valuable reference points that construction SMEs can relate to their own businesses and realise the business areas that needs improvement. Further, the case studies contribute towards the evidence base regarding the significance of EWE impacts on construction SMEs and the need for being proactive in addressing the risk within businesses. The need for such case studies was highlighted in a study commissioned by DEFRA, where it recommended the collation of a series of case studies showcasing the benefits of adaptation actions (Frontier Economics Limited, 2013a). Therefore, the critical reflection points highlighted within the case studies can contribute to DEFRA's initiative. The good practice accumulated via the case studies can also contribute towards UKCIP's showcasing of SME initiatives.

7.3.6 Contribution to research methodology

A mixed method research design was adopted within the study with a questionnaire survey and case studies consisting of semi-structured interviews and structured interviews. This is opposed to traditional positivist research methods dominant within construction management research. This answered the call for methodological pluralism

in construction management research (Love et al., 2002; Dainty, 2008). This research has shown that the mixed method research design adopted has not hindered the study, but has contributed to greater understanding of the phenomenon being studied. This is clarified by Adolphus (2013), who noted that the mixed method research approach adopted in this research study has not only complemented each other; but also has initiated new knowledge.

7.3.7 Dissemination of knowledge

Findings from this study have been published in peer reviewed journals, presented at international conferences and discussed at various workshops attended by academic and industrial participants as the research progressed (See Appendix – A for the list of publications). Further publications are in preparation and in review. Due to the timely and practical nature of the study, significant interest was generated when the findings were presented and discussed. Further dissemination options will be explored in line with the multi-disciplinary nature of the study.

7.4 Limitations of the study

The study was developed and conducted whilst addressing the issues of reliability, validity, and triangulation of research (see Section 3.9). Accordingly, a rigorous research process was adopted throughout the study. However, the study is not without limitations.

The focus of the study has been limited to construction SMEs who are contracting companies. This was desired due to the objectives of the study and the inherent nature of the construction industry. For example, consulting companies which are office based are likely to replicate SMEs in general. Whilst the focus of the study and the sample selected

for case studies are complementary to the research objectives, there is the limitation that the views of SMEs from the entire industry might not have been represented within the study. However, this limitation in scope is acceptable as contracting companies whose main business activities relate to construction projects are the ones likely to represent a different perspective to that of general SMEs in relation to EWEs.

The sample of construction SMEs involved in the questionnaire survey stage was small. However, as the questionnaire survey was conducted as an exploratory study the sample size adequately addressed the objectives of the survey. Further, this limitation was overcome by conducting detailed case studies of construction SMEs. Distribution of a questionnaire via the FSB was a limitation, as only FSB members were involved in the survey. Therefore, viewpoints that are not part of the FSB may not have been represented within the survey. However, close similarity between the exploratory questionnaire survey sample and the SME population in terms of size and industry sectors suggests that the sample is representative of the SME sector.

EWEs experienced by case study construction SMEs included, in the main, heavy snowfall and low temperatures. Heavy rainfall, flooding and heat waves were also reported. The focus of the case studies however, have been on EWEs that were considered significant by the individual case study SMEs, based on their previous experiences and impacts associated with those events. Therefore, the findings are likely to be biased towards EWEs that have had a significant impact on the case study SMEs. This limitation has been addressed by comparing and contrasting study findings with that of existing literature; for example studies on flooding.

As the two case study SMEs were medium sized construction companies (see Section 3.7.1.2), the findings of the case studies can, in the main, be attributed to medium sized construction companies. However, steps such as cross-analysis with the questionnaire survey findings where the majority of the sample was micro sized SMEs, and comparison with the findings of other studies on SMEs, have been followed to increase the applicability of the study's findings to the broader range of construction SMEs. Further, the validation process of the resilience assessment template included two micro sized construction SMEs to assure its applicability to smaller construction SMEs.

7.5 Recommendations

Based on the findings of the study several recommendations can be made for policy making and practice in the subject domain. These recommendations are outlined below.

7.5.1 Accumulation and dissemination of information on EWE resilience among construction SMEs

The case study findings revealed that construction SMEs would like to receive further information on possible impacts of EWEs, business consequences, and assessing and enhancing their resilience. For example, CSA1 stated that *"I think more information certainly would be beneficial. I think there is very little information about how to combat or deal with these situations, and that is not necessarily just for SMEs, nationally"*. Similar concerns were raised by CSB1, where it was stated that *"I presume that summarising on paper the impact of extreme weather on us is important, so people can look at it and see, like say the policy makers can see what may need to change"*. Therefore, it is recommended that a knowledge base of information related to EWEs, specifically from a

construction SME perspective, (e.g. case studies as discussed in Section 7.3.5) be developed and the information disseminated among construction SMEs.

7.5.2 Clarity in standard forms of conditions of contract

Lack of clarity in conditions of contract was highlighted, especially by the respondents of CSB (see Section 5.2.9). Therefore, there seems to be the need for making construction SMEs aware of how the conditions will apply, especially amidst increasing occurrences of EWEs. Similar to other information discussed in Section 7.5.1, information on contract conditions can also be disseminated among construction SMEs via general business support organisations such as Business Link and Federation of Small Businesses, construction specific support organisations such as Constructing Excellence in the Built Environment and Considerate Constructors, and professional institutions such as the Royal Institution of Chartered Surveyors and the Chartered Institute of Building.

7.5.3 Enhancing the skills and competencies of construction professionals

Discussions with the case study respondents pointed out the necessity for qualified and experienced professionals to address EWE risk within estimating and bidding practices, and especially in preparing and submitting claims for approval (see Section 5.1.4, 5.2.7). This suggests that competencies in claims preparation, informed bidding etc, in relation to EWEs should be key competencies sought by smaller construction companies, in order to be resilient to EWEs and to gain a commercial advantage. As the number of professionals employed by a construction SME will be limited, it is important that those employed are adequately competent in handling EWE related issues to the advantage of their employer. Therefore, it can be recommended that such skills and competencies within the study programmes of related disciplines, such as construction management,

quantity surveying, and civil engineering should be mainstreamed. The need for enhancing the understanding of EWEs among construction professionals has also been identified in previous research (Bosher et al., 2007a; Haigh and Amaratunga, 2010; Wedawatta et al., 2012).

7.5.4 Improving the accuracy and reliability of EWE prediction data

Better EWE prediction data was identified as a key requirement by the case study respondents. It is comprehensible that this is of vital importance for construction SMEs, if they are to plan site activities accordingly (see Section 6.4). It was stated by CSA1 that *“one thing that we could do is to relocate, redistributing work force to jobs that are not affected by the weather. So if we can get assertive weather warnings in advance it will certainly help”*. Similar concerns were raised by the respondents from CSB. Uncertainty associated with EWE disruptions has implications such as discouraging construction SMEs from addressing the risks which may lead to lower construction activity if the SME is over cautious, or could lead to significant negative impacts if the risk is underestimated. Therefore, it is important that construction SMEs are provided with accurate, reliable and timely EWE warnings possibly through the mediums preferred as identified in the Section 4.9. Also, it is worth making construction SMEs aware of existing EWE warning systems including Environment Agency warnings, as the exploratory survey found such initiatives are less popular among construction SMEs.

7.6 Further research

7.6.1 Further case studies with construction SMEs

As part of the study case study SMEs were investigated in detail with regard to their previous EWE experiences, impacts, risk management and resilience. These two case studies were selected purposively to adequately address the research objectives of the study. Whilst the case studies have provided a comprehensive understanding of issues pertaining to resilience of construction SMEs to EWEs, further studies involving a wider range of construction SMEs is recommended especially for the benefit of construction SMEs. It is recommended that impacts and strategies for resilience of a range of construction SMEs are documented, representing different trades and sizes in relation to different EWEs. Making such information available to construction SMEs will be largely beneficial to smaller construction SMEs, in realising the potential impacts of EWEs on their business and potential means for addressing the risk.

7.6.2 Similar studies in countries with different EWE risk profiles

The study was conducted on construction SMEs in the UK. Therefore, findings of the study can be replicated for countries with a similar EWE risk profile and a business / SME context. Similar studies can be conducted in countries with different EWE risk profiles and business contexts. For example, weather that could be extreme for a particular country or region could well be the norm in a different country or region. Therefore, business practices in a particular country or a region can provide invaluable lessons for SMEs in another country or a region. Such further research will contribute towards knowledge bases that could contribute towards construction SMEs and businesses in general to adapt to the increasing risk of EWEs.

7.6.3 Further research involving the supply chain partners of construction SMEs

Further research can be conducted involving supply chain partners of construction SMEs, in order to capture how the risk of EWEs are assessed and transferred throughout the supply chain. This will provide a greater understanding of how EWE risk is perceived and addressed by a construction SME or a supply chain partner and how this affects other businesses in the construction supply chain. As the industry is characterised by its fragmented and adversarial nature and is being encouraged to develop collaborative working (Latham, 1994; Egan, 1998; Cabinet Office, 2011), it is important that ways and means of collaboratively managing the EWE risk among the supply chain of the industry and in projects are developed. Further studies involving the whole supply chain will be beneficial in this regard.

7.6.4 Further research on contractual provisions governing EWEs

The findings of the study revealed conditions of contract to be a strategy available to and utilised by construction SMEs to protect themselves against damage caused by EWEs (see Sections 5.1.5.7 and 5.2.5.4). However, the findings also revealed that construction SMEs have found it difficult to assess how the conditions governing EWE disruptions have to be applied in frequent EWE situations. Therefore, the need for improving the clauses governing EWE disruptions as well as understanding among construction SMEs on such clauses was noted (see Sections 5.2.8 and 5.2.9). Furthermore, construction SMEs were interested in investigating risk sharing measures that can be facilitated in contracts (see Sections 5.1.7 and 5.2.7). Therefore, there seems to be scope for further research on clauses governing EWE risk and how the existing clauses can be further developed to reflect the needs of the industry and increasing frequency and intensity of EWEs.

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Appendix

Appendix A – List of publications

Journal papers (peer reviewed)

1. Wedawatta, G. & Ingirige, B. (2012) Resilience and Adaptation of Small and Medium-sized Enterprises to Flood Risk. *Disaster Prevention and Management*, 21(4), 474-488. (DOI 10.1108/09653561211256170)
2. Wedawatta, G., Ingirige, B., Jones, K., & Proverbs, D. (2011) Extreme Weather Events and Construction SMEs: Vulnerability, Impacts and Responses. *Structural Survey*, 29(2), 106-119. (DOI 10.1108/02630801111132795)
3. Wedawatta, G., Ingirige, B. & Amaratunga, D. (2010) Building up Resilience of Construction Sector SMEs and their Supply Chains to Extreme Weather Events. *International Journal of Strategic Property Management*, 14(4), 362-375. (DOI 10.3846/ijspm.2010.27)
4. Wedawatta, G. Ingirige, B. & Proverbs, D. (2013) Impacts of Flooding on Businesses: The Case of the 2009 Flood Event in Cockermouth. *Journal of Flood Risk Management* (In Press, available online) (DOI 10.1111/jfr3.12031)

Journal papers in review

5. Ingirige, B. & Wedawatta, G. Putting policy initiatives into practice: Adopting an “honest broker” approach to adapting small businesses against flooding. *Structural Survey* (Submitted to a special issue on “Adaptation to Climate Change: the challenges and opportunities for the built Environment” – In review – Accepted subjected to corrections)

Book chapters

6. Ingirige, B. & Wedawatta, G. (2011) Impacts of Flood Hazards on Small and Medium Companies: Strategies for Property Level Protection and Business Continuity. IN LAMOND, J., HAMMOND, F. & BOOTH, C., PROVERBS, D. (Eds.) Flood Hazards, Impacts and Responses for the Built Environment. London, Routledge. 269- 280. (ISBN 978-1-4398-2625-6)

Research reports

7. Wedawatta, G., Ingirige, B. and Proverbs, D. (2012) Impacts of Flooding on SMEs and their Relevance to Chartered Surveyors, Royal Institution of Chartered Surveyors, London: UK.

Conference papers (peer reviewed)

8. Wedawatta, G., Ingirige, B & Proverbs, D (2012) Reinstatement of Flood Affected Property: Experiences of SMEs Affected by the 2009 Cockermouth Flood Event. IN Kashiwagi, D & Sullivan, K (Eds.) Proceedings of the RICS Construction, Building and Real Estate Conference (COBRA 2012), September 2012, Las Vegas, USA. 1906-1914 (ISBN 978-1-84219-840-7).
9. Wedawatta, G., and Ingirige, B. (2011) Case Study as a Research Strategy: Investigating Extreme Weather Resilience of Construction SMEs in the UK. ARCOM Doctoral Workshop on Building resilience and project management, International Conference on Disaster Resilience Kandalama, Sri Lanka.

10. Wedawatta, G., Ingirige, B. & Proverbs, D. (2011) Adaptation to Flood Risk: The Case of Businesses in the UK. International Conference on Building Resilience, July 2011, Kandalama, Sri Lanka.
11. Ingirige, B. and Wedawatta, G. (2011) SME Resilience to Extreme Weather Events: Important Initiatives for Informing Policy Making in the Area. International Conference on Building Resilience. July 2011, Kandalama, Sri Lanka.
12. Wedawatta, G., Ingirige, B. & Jones, K. (2010) Coping Strategies Against Extreme Weather Events: A Survey of SMEs in the UK. RICS Construction and Building Research Conference (COBRA) 2010, July 2010, Université Paris-Dauphine, Paris. (ISBN 978-1-84219-619-9)
13. Wedawatta, G., Ingirige, B. & Amaratunga, D. (2010) Developing a Conceptual Framework for Investigating the Resilience of Construction SMEs and their Supply Chains against Extreme Weather Events. RICS Construction and Building research conference (COBRA) 2010, July 2010, Université Paris-Dauphine, Paris. (ISBN 978-1-84219-619-9)
14. Wedawatta, G., Ingirige, B. & Amaratunga, D. (2010) Building up Resilience of Construction Sector SMEs and their Supply Chains to Extreme Weather Events CIB TG63 - Disasters and the Built Environment, CIB World Congress, May 2010, Salford, UK. 313-325. (ISBN 978-1-905732-90-6)
15. Wedawatta, G., Ingirige, B. & Jones, K. (2009) Climate Change and Construction Sector SMEs: Vulnerability, Consequences and Resilience IN Gattoni, L. P., Poli, T. & Paolini, R. (Eds.) 8th Workshop and Meeting of the CIB W108 – Climate Change

- and the Built Environment. March 2009, Politecnico di Milano, Milano. 12 -16.
(ISBN 978-88-387-4366-5)
16. Wedawatta, G., Ingirige, B. & Amaratunga, D. (2009) Effects of Extreme Weather Events on SMEs: A Literature Review and Synthesis. In Ahmed, V., Alshaw, M., Egbu, C. & Sutrisna, M. (Eds.) 9th International Postgraduate Research Conference (IPGRC). January 2009, Salford, UK. 3-14. (ISBN 978-1-905732-64-7)
 17. Ingirige, B. & Wedawatta, G. (2009) Utilising Intranet Technologies in Construction Sector SMEs: Building up Knowledge Bases for Extreme Weather Event Risk Management. Proceedings of the Joint International Symposium of CIB W055 & W065. September 2009, Dubrovnic, Croatia. 632-642.
 18. Ingirige, B., Wedawatta, G. (2009) Building Resilience against Extreme Weather Events: Coping Strategies of SMEs in the UK. Planning Meeting of the International Institute for Infrastructure Renewal and Reconstruction (IIIRR), July 2009, Galle, Sri Lanka.

Conference papers – Other (peer reviewed)

19. Kulatunga, U., Wedawatta, G., Parvez, A., Biswas, R., & Amaratunga, D (2012) Disaster Risk Reduction Measures in Bangladesh. IN Senaratne, S & Sandanayake, Y (Eds.) Proceedings of the Global Challenges in Construction Industry - World Construction Symposium, June 2012, Colombo, Sri Lanka. 209-220. (ISBN 978-955-4516-02-1).
20. Kulatunga, U, Wedawatta, G., & Amaratunga, D. (2012) Evaluation of Community Risk Assessment Method for Development of Disaster Risk Reduction Strategies and Climate Change Adaptation Plans. Breaking the Mould: Humanitarian Aid and

Empowering Local Communities Conference, August 2012, Durham University, Durham, UK.

Journal papers in review (Other)

21. Wedawatta, G. & Kulatunga, U. Amaratunga, D. & Parvez, A. Community Engagement for Enhancing Disaster Resilience: Infrastructure Requirements for South-Western Bangladesh. Asian Journal of Environment and Disaster Management (In Review).

Appendix B – CREW research project

Community Resilience to Extreme Weather - CREW, is an Engineering and Physical Sciences Research Council (EPSRC) funded research project which aims to gain a better understanding of the effects of extreme weather events on local communities, and to develop a set of tools for improving the resilience of local communities. The project exploited both physical and social sciences and is being conducted in collaboration with 14 UK universities. Key objectives of the project were to;

- Gain a better understanding of the impacts of extreme weather events (current and future) on local communities, based on three community groupings: householders, SMEs and decision makers;
- Integrate social and physical research to develop an improved understanding of risk from EWEs at the community level;
- Study the complex inter-relationships between community groups in order to improve our understanding of the risks, vulnerabilities, barriers and drivers that affect the resilience of a local community to extreme weather events;
- Quantify and rank a number of technical and adaptive coping measures for reducing vulnerability to extreme weather;
- Develop web-based information dissemination tools for integrating the project outputs. This will deliver maps, reports and guidance on impacts and resilience measures for extreme weather

The project consisted of six programme packages, which are identified below.

- PP1 Coping Technologies - People and Buildings
- PP2 Community Coping - Resilience capacity and coping strategies
- PP3 Impacts - Socio-Economic simulators (EWESEM)
- PP4 Hazards - Extreme Weather Event Simulators (SWERVE)
- PP5 Dissemination - Web-display and interface for programme outputs (WISP)
- PP6 Management - Project coordination and management

This doctoral research forms part of the PP2 programme package, which sought to investigate how community groups; policy makers, households and SMEs, respond to EWEs and study the complex relationships between these groups, in order to improve the understanding of the impact that these relationships have on community resilience. The research sought to understand reasons for uptake, or not, of coping strategies and to develop an integrated toolkit that supports the individual and collective actions of local policy makers, households and SMEs, leading to improved local community resilience.

Appendix C – CREW project terminology (Key terms)

Adaptation:	Initiatives and measures to reduce the vulnerability of humans and human systems to actual or expected climate change effects, including increases in the intensity or frequency of EWEs.
Adaptive capacity:	The ability of a system to implement effective adaptation measures.
Climate change:	Climate change refers to a change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties, and which persists for an extended period, typically decades or longer.
Coping capacity:	The ability of people or organizations to limit adverse consequences of EW hazards, using available resources and capabilities.
Coping mechanisms/strategies:	Actions that increase the ability to prevent, tolerate, avoid and/or recover from EWEs and impacts
Disaster:	A serious disruption of the functioning of a community causing widespread human, material, economic or environmental losses which exceed the ability of the affected community to cope using its own resources.
Extreme weather event:	Meteorological conditions that are rare for a particular place and/or time
Extreme weather hazard:	A potentially damaging phenomenon associated with extreme weather that may cause loss of life or injury, property damage, social and economic disruption or environmental degradation.

Mitigation:	Policies and action to reduce the sources of (or enhance the sinks for) greenhouse gases.
Resilience (to extreme weather):	The ability to prevent, withstand, recover from and learn from the impacts of EW hazards.
Risk:	The probability of harmful consequences or expected losses resulting from interactions between extreme weather hazards and vulnerable conditions.
Risk management:	The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of EWE hazards.
Vulnerability:	The characteristics and circumstances of humans and human systems that determine how susceptible they are to the impact of EW hazards.

References

Hallet S. (ed.) (2013) Community Resilience to Extreme Weather – the CREW Project: Final Report. 110.

Appendix D – Questionnaire survey template

Small and Medium-scale Enterprise (SME) Resilience to Extreme Weather Events

Questionnaire for Small and Medium Scale Enterprises (SMEs)

We kindly request you to take part in this questionnaire survey, which aims to study the resilience of Small and Medium-scale Enterprises to the effects of Extreme Weather Events, as part of a multi-disciplinary research project involving 14 UK universities. The questionnaire should take approximately 10 minutes to complete, and we acknowledge your kind contribution in this regard.

INTRODUCTION

In the UK, Extreme Weather Events (EWEs) such as floods, heatwaves and storms are increasing in frequency and severity. The intensity and frequency of such events are expected to further increase in future due to, now apparent, climate change. Thus, it is important that the local communities are prepared to prevent, withstand and recover from the impacts of such weather extremes. Addressing this important issue, the Engineering and Physical Sciences Research Council (EPSRC) funded a research project “Community Resilience to Extreme Weather Events – CREW”, aimed at gaining a better understanding of the effects of extreme weather events and to develop a set of tools for improving the resilience of local communities.

As part of the CREW research project, we intend to study how Small and Medium-sized Enterprises (SMEs) respond to extreme weather events and how their resilience can be improved so that they will be in a better position to manage the effects of such an event.

OBJECTIVES OF THE STUDY

- To understand the current decision making process of SMEs and their perceptions in response to EWEs.
- To identify inter-linkages and inter-dependencies between different stakeholder groups of a community.
- To identify and evaluate the usefulness of existing coping strategies/processes for EWEs and non-EWEs.
- Develop and test prototype coping strategies in the form of an integrated decision making framework and a software toolkit to support the individual and collective actions of local policy makers, households and SMEs, in such a way that the actions result in the improved resilience of local communities to EWEs.

BENEFITS TO SMEs

The integrated decision making framework to be developed will have immediate benefits for SMEs. It will allow SMEs to identify the risk of EWEs in their locality, consequences to their businesses and also how to be prepared to manage these consequences. This will allow them not only to minimise the negative effects of EWEs, but also to maximise the positive effects. The study will inform other community groups like local policy makers and

emergency services about the unique needs of SMEs, resulting in better service/assistance being received by SMEs. SMEs will also benefit from improved resilience of their local community as a whole.

DEFINITIONS APPLICABLE TO THE STUDY

Extreme Weather Events: Meteorological conditions that are rare for a particular place and/or time.
E.g. severe storms, floods, intense or prolonged high/low temperatures.
(In lay terms extreme weather also implies weather of sufficient severity to generate hazards that may cause loss of life or injury, property damage, social and economic disruption or environmental degradation etc.)

Resilience: The ability to prevent, withstand and recover from the impacts of Extreme Weather hazards

INSTRUCTIONS TO RESPONDENTS

1. Please click on the following link to access the questionnaire and complete it online.

[Link to Questionnaire](#)

2. If you prefer to receive a hardcopy of the questionnaire via post, please e-mail g.s.d.wedawatta@pgr.salford.ac.uk with your postal address.

CONFIDENTIALITY AND ANONIMITY

We can assure you that the data shall be treated confidentially and anonymity of both the respondent and company will be ensured at all times. However, participation in the survey is deemed to mean that the respondent has given his/her consent for us to use the data to achieve the research objectives as stated above.

FURTHER INFORMATION

If you require further information or any clarification, please contact the SME project team via the contact details stated below.

General information with regard to the CREW research project can be found in the project website at www.extreme-weather-impacts.net.

CONTACTS

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Small and Medium-scale Enterprise (SME) Resilience to Extreme Weather Events

Questionnaire for Small Businesses

The project team wishes to thank you for agreeing to provide data for the research project titled "Community Resilience to Extreme Weather (CREW). We can assure you that the data shall be treated confidentially and anonymity of both the respondent and the company will be ensured at all times. Further, the respondent has the option to withdraw from the survey at any time and there won't be any follow up activity in the event of withdrawal. However, participation in the survey is deemed to mean that the respondent has given his / her consent for us to use the data to achieve the research objectives as stated in the information sheet attached with this questionnaire.

General Information

1. Which of the following best describes the industry sector in which your business operates?

- | | |
|---|--|
| <input type="radio"/> Agriculture, Hunting and Forestry, Fishing | <input type="radio"/> Hotels and Restaurants |
| <input type="radio"/> Mining and Quarrying | <input type="radio"/> Transport, Storage and Communication |
| <input type="radio"/> Electricity, Gas and Water Supply | <input type="radio"/> Financial Intermediation |
| <input type="radio"/> Manufacturing | <input type="radio"/> Real Estate, Renting and Business Activities |
| <input type="radio"/> Construction | <input type="radio"/> Education |
| <input type="radio"/> Wholesale and Retail Trade, Repairs | <input type="radio"/> Health and Social work |
| <input type="radio"/> Other Community, Social and Personal Service Activities | |
| <input type="radio"/> Other | |

If Other, Please specify

2. How many people are employed by your organisation?

- | | |
|---------------------------------------|--------------------------------|
| <input type="radio"/> 0 (Sole Trader) | <input type="radio"/> 1 – 9 |
| <input type="radio"/> 10 – 49 | <input type="radio"/> 50 – 249 |
| <input type="radio"/> Over 250 | |

3. What is the annual turnover of your business (approximately)?

- | | |
|--|---|
| <input type="radio"/> Less than £49,000 | <input type="radio"/> £50,000 – £99,000 |
| <input type="radio"/> £100,000 – £249,000 | <input type="radio"/> £250,000 – £499,000 |
| <input type="radio"/> £500,000 – £999,000 | <input type="radio"/> £1,000,000 – £4,999,000 |
| <input type="radio"/> More than £5,000,000 | |

4. Is your organisation a?

- | | |
|-----------------------------------|-----------------------------------|
| <input type="radio"/> Sole Trader | <input type="radio"/> Partnership |
| <input type="radio"/> Company | |
| <input type="radio"/> Other | |

If Other, Please specify.

5. Regarding your business premises, do you?

- ☐ Own freehold premises
☐ Rent premises
☐ Lease premises
☐ Work from home
☐ Other

If Other, Please specify.

6. Please indicate the job title of the person completing this questionnaire

Past experience of Extreme Weather Events

7. Was your business affected/influenced by extreme weather during last 5 years?

	Very much affected	Much affected	Somewhat affected	Affected a little	Not affected at all
Floods	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Storms / hurricanes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Heat waves	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Extreme temperatures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strong rainfall	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Strong snowfall	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Drought	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If Other, Please specify.

8. Please indicate the years in which those weather extremes affected your business (Indicate more than one year if applicable. E.g. 2005, 2006).

Floods	<input type="text"/>
Storms / hurricanes	<input type="text"/>
Heat waves	<input type="text"/>
Extreme temperatures	<input type="text"/>
Strong rainfall	<input type="text"/>
Strong snowfall	<input type="text"/>
Drought	<input type="text"/>
Other	<input type="text"/>

If your business was not affected / influenced by any weather extreme, please go to the question number 16.

9. What were the effects experienced by your business due to the above extreme weather events?

- | | |
|---|---|
| <input type="checkbox"/> Loss of sales / production | <input type="checkbox"/> Disruptions to access to premises |
| <input type="checkbox"/> Increase in costs | <input type="checkbox"/> Increase in insurance cost |
| <input type="checkbox"/> Decrease in turnover / profit | <input type="checkbox"/> Increase in turnover / profit |
| <input type="checkbox"/> Damage to property / business premises | <input type="checkbox"/> Increase in sales / production |
| <input type="checkbox"/> Damage to stocks and equipment | <input type="checkbox"/> Decrease in cost |
| <input type="checkbox"/> Disruption to supply chain | <input type="checkbox"/> Increase in stakeholder reputation |
| <input type="checkbox"/> Physical / health impacts on employees | <input type="checkbox"/> Decrease in insurance premium |
| <input type="checkbox"/> Employee productivity losses | <input type="checkbox"/> Premises relocation |
| <input type="checkbox"/> Non attendance of employees | <input type="checkbox"/> Employees leaving the business |
| <input type="checkbox"/> No effect created on the business | |
| <input type="checkbox"/> Other | |

If Other, Please specify.

10. How would you rate the following statements in relation to your business's experience of extreme weather?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
• The business was aware of an extreme weather event occurring in the locality	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Adequate information / warning was received prior to the occurrence of the event	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
• Sufficient lead time was available to take action upon receiving information / warning	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. From where did you receive information / warning about the occurrence of the extreme weather (please select all that are applicable)?

- | | |
|--|---|
| <input type="checkbox"/> Met office announcements | <input type="checkbox"/> Environment agency |
| <input type="checkbox"/> Extreme weather warning system | <input type="checkbox"/> Newspapers |
| <input type="checkbox"/> Television / radio | <input type="checkbox"/> Internet |
| <input type="checkbox"/> Trade association or other business network | <input type="checkbox"/> Workshop / seminar / meeting |
| <input type="checkbox"/> Local authority | <input type="checkbox"/> Word of mouth |
| <input type="checkbox"/> Other | |

If Other, Please specify.

12. If your business was previously affected by an extreme weather event, did you receive any assistance / support from another party to recover from its effects and continue business operations?

- ☐ Yes
☐ No
☐ No support was required
☐ Other

If Other, Please specify.

14. If you received any assistance / support, from where did you receive such assistance / support? (Please indicate all that are applicable)

- | | |
|--|---|
| <input type="checkbox"/> Insurance company | <input type="checkbox"/> Emergency services |
| <input type="checkbox"/> Local authority | <input type="checkbox"/> Central government |
| <input type="checkbox"/> Local utility companies | <input type="checkbox"/> Environment agency |
| <input type="checkbox"/> Trade association or other business network | <input type="checkbox"/> Supply chain members / customers |
| <input type="checkbox"/> Neighbouring businesses | <input type="checkbox"/> Neighbouring households |
| <input type="checkbox"/> Other | |

If Other, Please specify.

15. How would you rate the assistance received from them?

	Strongly satisfied	Satisfied	Neither satisfied nor dissatisfied	Dissatisfied	Strongly dissatisfied
Insurance company	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Emergency services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Local authority	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Central government	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Local utility companies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment agency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trade association or other business network	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Supply chain members / customers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Neighbouring businesses	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Neighbouring households	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

16. Please answer the following questions in relation to the extreme weather event which caused most disruption to your business

- How many business days were lost due to this event?
- How much cost your business had to suffer (approximately)?
- How many days were required to get the business back in to work as usual?

Resilience to Extreme Weather Events

17. What are the steps that you have already taken to protect your business against the effects of extreme weather events (please select all that are applicable)

- | | |
|--|---|
| <input type="checkbox"/> Obtaining property insurance | <input type="checkbox"/> Obtaining business interruption insurance |
| <input type="checkbox"/> Developing a business continuity plan | <input type="checkbox"/> Premises improvements |
| <input type="checkbox"/> Installing flood defenses | <input type="checkbox"/> Planning your supply chain to minimise disruptions |
| <input type="checkbox"/> Relocation of your business premises | <input type="checkbox"/> Stock / equipment relocation |
| <input type="checkbox"/> Backing up your business data in another location | <input type="checkbox"/> Sign up with an extreme weather warning system |
| <input type="checkbox"/> Developing a flood plan | |
| <input type="checkbox"/> No step has been taken up to now | |
| <input type="checkbox"/> Other (please specify) | |

18. What are the steps that you may consider to take to protect your business against the effects of future extreme weather events? (Please select all that are applicable)

- | | |
|--|---|
| <input type="checkbox"/> Obtaining property insurance | <input type="checkbox"/> Obtaining business interruption insurance |
| <input type="checkbox"/> Developing a business continuity plan | <input type="checkbox"/> Premises improvements |
| <input type="checkbox"/> Installing flood defenses | <input type="checkbox"/> Planning your supply chain to minimise disruptions |
| <input type="checkbox"/> Relocation of your business premises | <input type="checkbox"/> Stock / equipment relocation |
| <input type="checkbox"/> Backing up your business data in another location | <input type="checkbox"/> Sign up with an extreme weather warning system |
| <input type="checkbox"/> Developing a flood plan | |
| <input type="checkbox"/> Other (please specify) | |

19. If you have not taken any steps up to now or you may not take any step in future to protect your business against weather extremes, please indicate why?

- | | |
|---|--|
| <input type="checkbox"/> Do not foresee an extreme weather event to affect the business in future | |
| <input type="checkbox"/> Impacts of extreme weather events are not significant enough to warrant any action | |
| <input type="checkbox"/> Too costly | <input type="checkbox"/> Lack of information / knowhow |
| <input type="checkbox"/> Information available are too complicated | <input type="checkbox"/> Protection measures are too complicated |
| <input type="checkbox"/> Too much workload | <input type="checkbox"/> Currently evaluating options available |
| <input type="checkbox"/> Other (please specify) | |

20. If your business decides to implement protection measures against weather extremes in future, who is likely to carry out these measures for you?

- ☐ The business itself
☐ The business with the help of another party
☐ Another party
☐ Other

If Other, Please specify.

21. How would you rate the following sources of information about extreme weather events?

	Very good	Good	Do not know	Poor	Very poor
Met office announcements	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Environment agency	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Extreme weather warning system	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Local authority	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trade association or other business network	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Newspapers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Television / radio	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Internet	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Workshop / seminar / meeting	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Word of mouth	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If Other, Please specify.

22. If an extreme weather event affects your business in future, from where do you expect to receive assistance/ support to recover from its effects and continue your business as usual?

- | | |
|--|---|
| <input type="checkbox"/> Insurance company | <input type="checkbox"/> Emergency services |
| <input type="checkbox"/> Local authority | <input type="checkbox"/> Central government |
| <input type="checkbox"/> Local utility companies | <input type="checkbox"/> Environment agency |
| <input type="checkbox"/> Trade association or other business network | <input type="checkbox"/> Supply chain members / customers |
| <input type="checkbox"/> Neighbouring businesses | <input type="checkbox"/> Neighbouring households |
| <input type="checkbox"/> Other | |

If Other, Please specify.

23. What assistance / support do you expect to receive in order to recover from its effects and continue your business as usual?

- | | |
|--|---|
| <input type="checkbox"/> Cleaning and restoration of premises | <input type="checkbox"/> Financial assistance |
| <input type="checkbox"/> Business continuity advise | <input type="checkbox"/> Legal advise |
| <input type="checkbox"/> Provide alternative / temporary business premises | <input type="checkbox"/> Advise on suitable coping measures |
| <input type="checkbox"/> Other | |

If Other, Please specify.

24. Please indicate the likelihood of moving your business to a different location, if:

	Very high	High	Somewhat	Little	Never
Your business is flooded once every two years	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your business is flooded once every five years	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Your business is flooded once every ten years	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

25. Please indicate the job title(s) of person(s) who is/are likely to take decisions with regard to extreme weather events in your business.

Supply chain issues with regard to Extreme Weather Events

26. Was your business affected due to supply chain disruptions caused by an extreme weather event? If so, to what extent?

	Very much	Much	Somewhat	A little	Not at all
Loss of utility services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Damage to / inaccessibility of road network	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cancellation of supplies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Delay of supplies in	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Higher cost of supplies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Higher cost of transportation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Longer transportation time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lower quality of supplies	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Failure of businesses in supply chain	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Change of demand for goods / services from customers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If Other, Please specify.

27. Were your supply chain partners affected due to your business being affected by an extreme weather event? If so, to what extent?

	Very much	Much	Somewhat	A little	Not at all
Cancellation of products / services	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Delay in delivering products / services to customers	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Higher price of your products	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Higher cost of transportation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Longer transportation time	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Cancellation of supplies to your business	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Withholding / delaying supplies to your business	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Other	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

If Other, Please specify.

Future involvement and comments

28. Please provide the name of your business (for our research use only, this will remain confidential)

29. Please indicate the local borough in which your business is located (for our research use only, this will remain confidential)

- | | |
|--|---------------------------------|
| <input type="radio"/> Bexley | <input type="radio"/> Bromley |
| <input type="radio"/> Croydon | <input type="radio"/> Greenwich |
| <input type="radio"/> Lewisham | |
| <input type="radio"/> Other (please specify) | |

30. Please select from the following options if you would like;

- ☐ To receive more information about the study
- ☐ To receive findings and results of the study
- ☐ To participate in a future survey in relation to this research study

31. If you have selected any of the options in Question 29 above, please provide your preferred contact details.

Address:	<input type="text"/>
Telephone:	<input type="text"/>
e-mail:	<input type="text"/>

32. If you have any other comments, please provide these in the box below.

Thank you

The project team wishes to thank you for your kind cooperation and assistance to make this research study a success.

If you require further information or any clarification, please contact the SME project team via following contact details.

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Appendix E – Case study interview guidelines – Construction SME

Semi-structured interview guidelines for SMEs

General information

1. Number of employees:
2. Number of years in business:
3. Number of years in current location:
4. Main business activities:

Extreme weather events and the business

1. Has your business experienced EWEs before?
 - a. If yes, when? What was the impact and how did you respond?
2. Do you think that EWE risk could have a critical impact on your business?
 - a. What kind of threat do you consider bigger (crime) and smaller.
3. Has the business considered EWEs before and done anything about them?
 - a. What could be done to increase the resilience of your business to EWEs?
 - b. What difficulties (if any) prevent you from implementing these measures at present, how could they be overcome?
4. Do you think your business is resilient enough to EWEs?
 - a. Where do you consider your business particularly exposed and or particularly strong?
5. What kind of support do you think might help enhance your preparedness for EWEs and assist in your recovery after the event?
6. Do you have any questions about making your business more resilient to extreme weather?

Appendix F – Case study interview guideline – Construction projects

Interview guideline for Site Management

1. Please give a brief description about the project
2. Who are the other organisations, supply chain members involved in the project?
3. Has this site experienced EWEs before?
 - a. If yes, when and what weather extremes
4. How were your site activities affected by this EWE?
5. What was the effect on cost, time and quality?
6. How did it affect your workforce?
7. How did it affect your supply chain members?
8. How did you respond to this event?
9. What are the lessons learned and coping strategies implemented to face a future EWE?
10. What kind of support do you think might help enhance your preparedness for EWEs and assist in your recovery after the event?
11. Do you have any questions about making your site more resilient to extreme weather?

Appendix G – Extended structured interview template

Discussion prompts for resilience assessment

These questions have been developed to facilitate completing the resilience assessment template. Therefore the questions can be used as prompts to generate discussion and information to complete the assessment.

1) How would flooding affect your markets?

- i) Does the organisation have contingency plans for EWE scenarios?
- ii) How will EWEs affect the demand for what you offer?
- iii) How will EWEs affect customer access to your goods and services?
- iv) Will your business's image be affected/enhanced by EWEs?
- v) Do you think that your response to EWEs can affect your ability to compete with your rivals?
 - (1) Can you identify opportunities to tailor your products / services to EWEs and post EWE situations?

2) How would EWEs affect the financial situation of your business?

- i) Does the organisation have contingency plans for EWE scenarios?
- ii) Will the risk of EWEs have an adverse impact on your ability to attract
 - (1) Investment
 - (2) loans, and
 - (3) Insurance (check existing insurance)
- iii) How will EWEs affect your ability to meet your liabilities to stakeholders
 - (1) How could EWEs affect the image of your company to your stakeholders?
- iv) Will your business be required to address any statutory rules or regulations regarding EWEs? (e.g. flood protection, health and safety)

3) How vulnerable are your logistics and supply chains to EWEs?

- i) Does the organisation have contingency plans for extreme weather scenarios?
- ii) Are your transport and delivery systems liable for disruptions by EWEs?
(Which ones, where and when?)
- iii) How would the loss of utility services due to EWEs affect day-to-day operations?
- iv) How will EWEs affect the procurement of goods and services to your business?
- v) How susceptible are your key supply chains to failure due to weather extremes? (example)

4) How will EWEs affect your business premises?

- i) What are the coping measures that are already in place to reduce the risk to your business premises?
 - (1) What are the coping measures you expect to implement in future? (flood gates, alternative premises)
- ii) How and where are your business premises susceptible to EWEs?
- iii) How will the following be affected in the event of EWEs?
 - (1) access
 - (2) stocks
 - (3) equipment
 - (4) business information and data,
 - (5) Workplace environment (the health and safety of your employees)?
- iv) Why is the business located here?
 - (1) What level of flood frequency would impact a decision to relocate?

(2) How much would rents have to increase in this locality for you to consider moving?

5) How do you think the weather extremes can affect your workforce?

- i) Does the organisation have contingency plans for extreme weather scenarios?
- ii) Has the company allocated roles and responsibilities amongst employees on how to deal with weather extremes?
- iii) What proportion of your workforce is local, how do your employees travel to and from your office and how are weather extremes likely to affect this?
- iv) Do you think that your employees have the necessary skills and competencies to deal with an extreme weather situation?
- v) Can you foresee any impacts on employee retention and recruitment during and after an extreme weather event?

6) How will weather extremes affect your production processes and services you offer?

- i) Does the organisation have contingency plans for extreme weather scenarios?
- ii) How will EWEs affect your site activities, projects?
- iii) What will happen to the cost of production after a weather extreme?

(1) How may weather extremes cause delays and overruns in your site activities?

- iv) Do you foresee that EWEs will lead to quality issues of site activities?

Appendix H – EWE Resilience Assessment Template

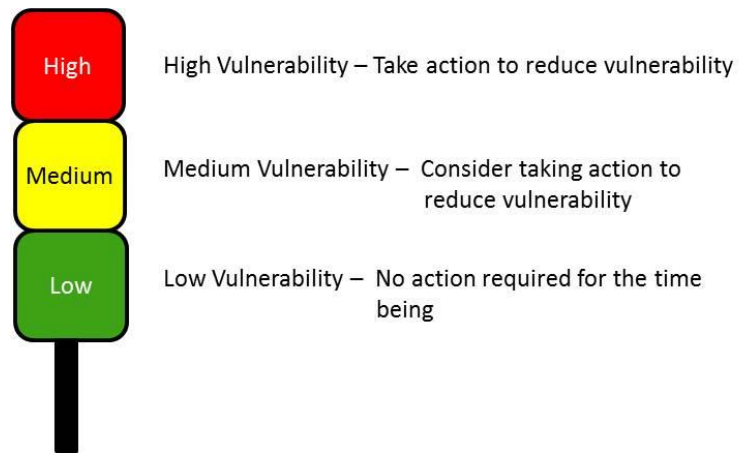
Extreme weather resilience assessment template for construction SMEs

Assessment of business resilience to extreme weather events

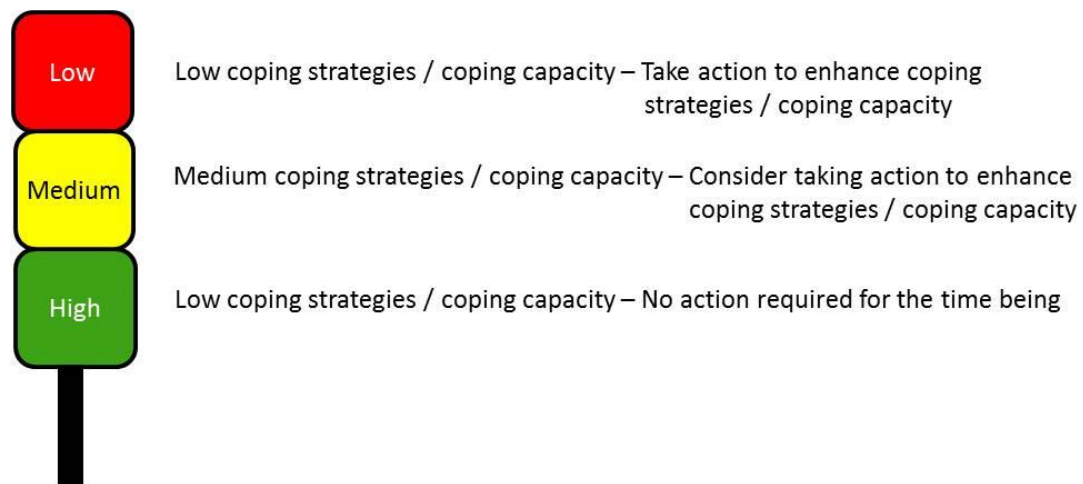
Terminology

Vulnerability	The characteristics and circumstances pertaining to your business that determine how susceptible your business is to the impact of EW hazards
Coping strategies	Actions that increase the ability to prevent, tolerate, avoid and/or recover from EWEs and impacts
Coping capacity	The ability of your business to limit adverse consequences of EW hazards, using available resources and capabilities
Resilience	The ability of your business to prevent, withstand, recover from and learn from the impacts of EW hazards

Assessment of Vulnerability



Assessment of Coping strategies and Coping capacity



Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Markets in which the business operate									
Demand for goods/services Whether the EWEs are capable of having an impact on the demand for goods / services you offer?									
Access of customers to goods/services you offer How can EWEs affect the ability of your customers to access the goods / services you offer (your markets)?									
Alternative products/services Are there opportunities to offer alternative products / services to address weather extremes (ability of your company to make use of EWEs)?									
Business reputation / image How will the reputation / image of your business among the customers be affected if your business is affected by an EWE?									
Competitiveness Can EWEs affect your ability to compete with your rival companies?									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Financial situation									
Turnover and cash flow How can EWEs impact on the ability of your business to attract investments, obtain loans and maintain your cash flow?									
Investment, loans How will EWEs affect the ability of your business to attract investments, obtain loans?									
Insurance Will EWEs lead to increased insurance premiums, withdrawal / refusal of insurance policies?									
Liabilities How can EWEs affect your ability to meet the liabilities towards internal/ external stakeholders?									
Statutory compliance Are there any statutory rules and regulations addressing the risk of EWEs that you have to comply with?									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Supply chain and logistics									
Transport and delivery systems How can EWEs affect transport and delivery systems to and out of your business?									
Supplies of goods and services How can EWEs affect the availability, price and procurement of goods and services required for your business?									
Utility supply How can the utility supplies be affected by EWEs and how will that affect your business activities?									
Communication network How can your communication network be affected by EWEs and how will that affect your business activities?									
Businesses in the supply chain Are the businesses in your supply chain at risk of being affected by EWEs and if so, how can this effect on your business activities?									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Business premises									
Vulnerability to flooding and other EWEs How vulnerable your business premises are to flooding and other EWEs?									
Stocks and equipment Can your stocks and equipment be damaged by floods and other EWEs?									
Internal environment, working conditions Can EWEs affect the internal environment of your business premises and thereby create productivity, health and safety issues?									
Business information, data To what extent can EWEs affect your business information and data (both paperbound and electronic)?									
Accessibility How can EWEs affect the access to your business premises?									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Work force									
Travel arrangements How can EWEs affect the travel arrangements of your staff, availability of alternative arrangements?									
Employee retention How might the risk of EWEs affect employee retention and your ability to attract new employees?									
Awareness What is the level of awareness of your employees regarding the risk of EWEs, health and safety concerns?									
Skills and competencies Do your employees possess the necessary skills and competencies to deal with an EWE situation?									
Roles and responsibilities Have roles and responsibilities of your employees on how to work during an EWE situation, health and safety issues been clearly identified and communicated?									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Production processes and services offered									
Disruptions to produce / offer services How can EWEs affect production of goods / services you offer (e.g. site activities)?									
Productivity How can EWEs affect the productivity of your production processes / services (e.g. productivity in site activities)?									
Cost How can EWEs affect the costs of production / delivering services (e.g. cost of construction work)?									
Quality, product standards How can EWEs affect the quality, product standards of goods / services you offer (e.g. quality of construction work)?									
Time How can EWEs affect the time to produce / offer services (e.g. project duration)?									

This checklist intends to assist businesses in determining how resilient the different aspects of the business are to extreme weather events (e.g. flooding, heavy rainfall, heavy snowfall, heat waves). The template is neither comprehensive nor definitive. The checklist however can be used as a simple guidance to see how critically extreme weather events can affect different aspects of your business and which aspects require your attention. Please note that there may be other factors that you have to consider, which are specific to your organisation, in addition to the factors identified in this checklist.

The main influence for this checklist has come from the UKCIP BACLIAT toolkit (Metcalf et al., 2009) and has been compiled using different tools currently available to determine the resilience of businesses to climate change and other hazards. The reference list is indicated below.

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Appendix I – EWE Resilience Assessment of CSA

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Markets in which the business operate									
Demand for goods/services									
Access of customers to goods/services you offer									
Alternative products/services									
Business reputation / image									
Competitiveness									
Financial situation									
Turnover, income generation and cash flow									
Investment, loans									
Insurance									
Liabilities									
Statutory compliance									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Supply chain and logistics									
Transport and delivery systems									
Supplies of goods and services									
Utility supply									
Communication network									
Businesses in the supply chain									
Business premises									
Vulnerability to flooding and other EWEs									
Stocks and equipment									
Internal environment, working conditions									
Business information, data									
Accessibility									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Work force									
Travel arrangements									
Employee retention									
Awareness									
Skills and competencies									
Roles and responsibilities									
Production processes and services offered									
Disruptions to production / offer services									
Productivity									
Cost									
Quality, product standards									
Time									

Appendix J – EWE Resilience Assessment of CSB

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Markets in which the business operate									
Demand for goods/services									
Access of customers to goods/services you offer									
Alternative products/services									
Business reputation / image									
Competitiveness									
Financial situation									
Turnover, income generation and cash flow									
Investment, loans									
Insurance									
Liabilities									
Statutory compliance									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Supply chain and logistics									
Transport and delivery systems									
Supplies of goods and services									
Utility supply									
Communication network									
Businesses in the supply chain									
Business premises									
Vulnerability to flooding and other EWEs									
Stocks and equipment									
Internal environment, working conditions									
Business information, data									
Accessibility									

Business areas	Vulnerability			Coping strategies			Coping capacity		
	High	Medium	Low	High	Medium	Low	High	Medium	Low
Work force									
Travel arrangements									
Employee retention									
Awareness									
Skills and competencies									
Roles and responsibilities									
Production processes and services offered									
Disruptions to produce / offer services									
Productivity									
Cost									
Quality, product standards									
Time									

Appendix K – Expert Opinion on EWE Resilience Assessment Template

Table below briefs the key comments of the experts on resilience assessment template and how the comments were addressed.

Expert	Key comments	Response
Academic 1	C1 Template has five levels of vulnerability, coping strategies and coping capacity. This will make it difficult for SMEs to assess how to rank each item. Suggest reducing the levels provided.	R1 Template was revised to include three levels of assessment; high, medium and low.
	C2 Each sub-business area to include a short description of what it means, what is included under the topic.	R2 Brief description of each sub-section was included.
Academic 2	C3 Terms like vulnerability and resilience have multiple definitions. Better to include how each term is defined for the purpose of the assessment.	R3 Definitions of key terms have been included as part of the assessment template.
SME 1	C4 The template does not say what to do if vulnerability or coping strategies are high or low.	R4 Level of assessment was reduced to three as mentioned in R1. Actions to be taken for each level were introduced in the form of a traffic light system.
	C5 Can we introduce possible ways	R5 The purpose of the template is

	of addressing different issues?	to act as a tool for assessing resilience. As suitable solutions may vary depending on the context of a particular SME, this is left at the discretion of the SME or the expert conducting the assessment.
SME 2	C6 Some SMEs may wish to consider issues additional to what is identified in the template. It will be better to make it clear that this may be the case.	R6 A note was added to make it clear that the template is not comprehensive and that there may be additional issues an SME may wish to consider. Such issues can be accommodated within the template.